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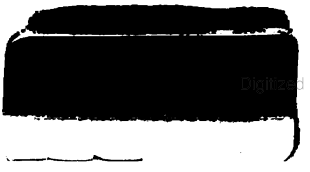

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NEW SOUTH WALES.

DEPARTMENT OF MINES AND AGRICULTURE.

GEOLOGICAL SURVEY.

E. F. PITTMAN, A.R.S.M., Government Geologist.

MINERAL RESOURCES.

No. 1.

NOTES ON CHROMIC IRON ORE:

Its Modes of Occurrence, Mining, Dressing, Uses, and Value;

WITH A

REGISTER OF NEW SOUTH WALES LOCALITIES.

BY

J. E. CARNE, F.G.S.,

GEOLOGICAL SURVEYOR.

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NOTES ON CHROMIC IRON ORE:

Its Modes of Occurrence, Mining, Dressing, Uses, and Value;

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REGISTER OF NEW SOUTH WALES LOCALITIES.

The chrome mining industry in New South Wales is of very recent date, though an abortive attempt was made to inaugurate it as early as 1882 in connection with deposits at Bowling Alley Point, Peel River. Trial parcels dispatched at that time, aggregating 100 tons, tested the market in Melbourne, Liverpool, and London. The highest realization, however—viz., 70s. per ton—was insufficient for profitable working under then existing conditions of land carriage, &c.

Attention was next directed to the chromite deposits of the Clarence River District; and, with a view of eliciting information as to the possibilities of the industry in that locality, Mr. Geological Surveyor (now Professor) David was instructed in 1891 to examine the outcrops. Extracts from his published report bearing on the mode of occurrence, quality, and probable extent of the ore bodies will be found under the head of "Gordonbrook" in the register of occurrences in these Notes. No practical attempt to test the market value of the ore, or the feasibility of profitable working, appears to have followed at that time.

In 1892, Mr. Wright, a chemist at Mittagong, interested himself in a group of chromite deposits on the east fall of Mooney Mooney Range, about 4 miles north-easterly from Coolac railway station. These eventually became the scene of the first practical mining operations, over 2,000 tons being dispatched from them during 1894 and 1895. The site, originally known as Wright's Mine, afterwards became the Vulcan Mine.

The opening of the Coolac Mine directed attention shortly afterwards to another group of deposits on the north and south falls of Mount Lightning, about 5 miles southerly along the same range, of which Mount Lightning is an isolated mass cut off by the intersecting channels of the Murrumbidgee River and Adjungbilly Creek, about 18 miles above the town of Gundagai (on the same river), the terminal railway station in that direction.

Several large ore-bodies occur on the flanks of the mountain, those on the north fall being designated Quilter's Mines, and those on the south Mount Mary Mine. Under this heading descriptions will be found in the Register.

Practical mining and export began in this district in 1893, which caused not only local prospecting activity, but also general search throughout the Colony wherever serpentine was known to exist. Numerous discoveries of chromite followed, but only in the Gundagai-Tumut District did they become a source of profitable mining enterprise. In other localities, distance of land carriage in some instances, and inferior quality in others, retarded or altogether deterred extended prospecting.

The successful operations achieved in the Gundagai district stimulated further effort in that of the Clarence River, a fresh attempt being made in 1895 to turn those of Gordonbrook to account. A shipment of 30 tons was

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dispatched to test the market, with what financial result is not known; evidently, however, it not was sufficiently encouraging for continued effort. Lengthy land carriage and moderate quality combined are believed to have been serious obstacles to success in this instance—obstacles, however, capable of being modified or obviated in the future by improved roads and methods of ore dressing and concentration.

During 1894, 1895, and 1896 the chrome mining industry continued to flourish, the exports being 3,034, 4,299, and 3,851 tons respectively, but latterly it has languished and the output depreciated in consequence. The export for 1897 amounted to 3,379 tons, but a considerably less amount was actually mined during the year. The present is, therefore, an opportune time to review the situation and discuss the causes of fluctuation. A glance at the principal sources of the world's annual production of chromite may also be advantageously taken, especially for purposes of comparison of its chief modes of occurrence. It will also be useful to note its uses and value, and the latest methods of dressing and concentration of the crude ore for market.

Sources of Supply.

The principal supplies of chromite are drawn from Turkey, Russia, Greece, California, Canada, New Caledonia, and New South Wales. Of these countries, Turkey and Russia are reported to be the largest producers.

The following particulars are extracted from volumes ii and v of "Mineral Industry"*:—"The chrome deposits of Turkey, in the Province of Brousa, in Asia Minor, have for many years afforded the largest supply for the world's markets; but recent reports are to the effect that the supply is showing signs of exhaustion especially as regards the richer grades.

The Turkish ores are noted for their richness and freedom from silica, which is an objectionable ingredient equally in furnace lining and in the manufacture of bichromate salts.

From Macedonia the export is increasing, owing chiefly to the increased facilities of transport to seaboard. The best grades assay 55 per cent. chromium sesquioxide. The exports are reported to amount to 10,000 to 12,000 tons per annum.

For comparison, and as an index to values, the following analyses of Turkish ores are taken from Vol. v, page 155, of the work already quoted:—

	(1)	(2)	(3)
Sesquioxide of chromium	55·04	51·70	56·80
Protoxide of iron	12·63	14·20	12·06
Alumina	11·84	14·10	14·00
Magnesia	16·19	14·30	15·00
Silica	2·00	3·50	1·45
Lime	1·46	1·70	0·70
Water	0·40	0·30	0·15
	99·56	99·80	100·16

The value of the above ores is stated to have been (at the then ruling market rates, 1893), £5 10s. per ton in Europe for 50 per cent. chromium sesquioxide, with 5s. per unit additional for each unit above 50 per cent.†

* The Mineral Industry, its Statistics, Technology, and Trade, 1893, ii, p. 155. *Ibid*, 1896, v, pp. 119–21.
† Mineral Industry, 1893, ii, p. 155.

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The Russian chromite deposits occur in the Ural Mountains. Formerly the ore raised was exported, but the recent local establishment of bichromate manufactories absorbs almost the entire output, which amounts to about 2,000 tons annually.

The Grecian output is reported to be very irregular, ranging from 200 to 1,400 tons per annum.

Though previously mined in large quantities for a long period in Maryland and Pennsylvania, U.S., chromite is now practically only produced in California. The most important deposits occur in Sans Luis Obispo County, but the ore is reported to be too low grade and scattered to pay at present prices. The average grade of California ores, in fact, is low, ranging from 43 to 47 per cent. Under the head of concentration, further reference will be made to them.

The production for 1895 amounted to 1,740 tons; and for 1896, 786 tons.

The production of chromite in Canada is of very recent date, the recorded output prior to 1894 only amounting to 50 tons. The output for 1895 was 3,177 tons; and for 1896, 2,362 tons.* The deposits occur irregularly and in small pockets in the serpentine belts of Quebec. The ore is of comparatively low grade, and is principally used for furnace lining in Pennsylvania.

Large quantities of chromite are reported to be again coming forward from New Caledonia, where large and rich deposits occur on the seaboard. The following description is from "Mineral Industry" †:—"Chrome iron ore occurs in great abundance in New Caledonia, where it was first mined in 1875, the ore being a constant associate of the serpentine rock of which a great portion of the island is composed. The most important deposits are those of Mont d'Or, N'Go River, and Canoe Bay, which are near the sea, and are connected with the port of shipment by a short railway. The ore exported averages 50 per cent. $Cr_2 O_3$. Alluvial ores are also met with at a great number of points in the south of the island, forming beds 30 inches in thickness. . . . . There are also in New Caledonia large deposits of iron ore, containing 50 per cent. of iron and 2 to 5 per cent. of chromium sesquioxide. These occur in large masses of red clay in the serpentine country rock, which have been formed from the decomposition of the rock itself. This ore is low in phosphorus."

A similar iron ore is reported to occur in large quantity in Tasmania.

The chrome mining industry in New Caledonia is most advantageously circumstanced as regards proximity to seaboard, purity, and low-priced (convict and native) labour; hence it will always be a formidable rival to Australian chrome mining, where the conditions are not so favourable.

Detailed descriptions of the known New South Wales deposits will be found in the Register forming part of this paper.

From New Zealand, chromite was exported for a few years prior to 1866, but ceased in that year. At Dun Mountain, in the Nelson District, bands of the mineral 10 feet and 15 feet thick are reported. The Government Geologist, Mr. Alex. McKay, reports‡:—"Chrome ore occurs in New Zealand, chiefly in association with the magnesian rocks of the Dun Mountain mineral belt, in the Nelson provincial district. Associated with rocks of the same age and character, it also occurs in the mountainous district of North-west Otago and the southern parts of Westland.

"The chief developments of ore (in the Nelson District, J.E.C.) are found between the Upper Maitai Valley and the Lea River, a distance along the mineral belt of 12 miles. The ore occurs in elliptical masses, usually at a

* The Statistical Year Book of Canada, 1896, p. 102.
† The Mineral Industry: its Statistics, Technology, and Trade, 1893, ii, p. 156.
‡ The New Zealand Record, 1897, i, No. 5, p. 229.

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given distance from the north-west margin of the mineral belt. Some of these deposits are of considerable size, and the total of the ore exported from Nelson (5,666 tons, J.E.C.) was mainly from one outcrop supplemented by a lesser quantity from Little Ben Nevis."

Large chromite deposits have lately been discovered in Newfoundland, and are now being opened up. There are, in addition to the above, other less important sources of supply, which need not be mentioned here.

Modes of occurrence of Chromite.

Under this heading, attention will only be paid to occurrence in commercial quantity. The mode of occurrence of commercial chromic iron ore in all producing countries is characterised by uniformity of physical conditions. As a general rule, it forms "bunches" or "pockets" in serpentine, usually of comparatively small size; and occasionally in alluvial deposits resulting from weathering and denudation of the enclosing rock. A few notable exceptions to the general rule regarding size of chromite bunches occur in Turkey, and in Maryland, and Pennsylvania, in the United States; and, it is believed, also in New Caledonia. A few large deposits in Turkey, have for nearly fifty years, continued to afford the principal part of the World's supply. According to Dr. D. T. Day*, Reed's Mine, Harford County, Maryland, produced over 100,000 tons of ore before exhaustion. Another very notable exception was the Great Wood Pit, Lancaster, Pennsylvania, which, according to the same authority, was worked to a depth of 700 feet, and for forty or fifty years afforded the greatest part of the world's supply.

The following description of the occurrence of chromite covers the general run of chromite deposits, and is especially applicable to those of New South Wales so far discovered:—"The chrome mining industry in California has never been put upon a permanent basis, however, owing chiefly to the irregularity in the occurrence of the mineral and the peculiar local conditions. As elsewhere in the world, the chrome ore there is found in serpentine, whence it is easily mined, but it usually occurs in small pockets, which are soon exhausted; indeed, as a rule, the deposits are too small to warrant the outlay of much capital for their exploitation, and mining is consequently comparatively expensive."†

In Turkey, the oreforms irregular pockets and masses in serpentine, which are worked in open cut.

The Russian deposits are classified by Gustave Rose under three heads:—(1) Those which occur in large granular masses in serpentine; (2) those where the mineral is finely disseminated through the rock; and (3) in alluvial deposits.‡

In "A Treatise on Ore Deposits" by J. A. Phillips and Henry Louis, 1896, p. 182, the following extract is quoted from Vogt:—"Deposits of chromite all the world over are basic magmatic segregations from peridotite, occurring as lenticular masses of varying dimensions in peridotite or in serpentine, resulting from the alteration of the rock"; in other words, the chromite segregated into masses whilst the original matrix—peridotite—was in the condition of a pasty or viscid magma.

Professor Garrison describes different forms of chromite deposits thus§:—"They have no orderly mode of occurrence or of extension of figure. They are neither veins nor beds nor fissures, but are ore pockets, each of which must be considered as a complete unit, having no relation whatever to any

* The Mineral Industry, 1893, ii. † *Ibid*, pp. 151-2. ‡ *Ibid*, 1893, ii, p. 158.
§ Ann. Rept. U.S. Geol. Survey, 1895-96, xvii, pt. iii, pp. 261-272.

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other pocket in the region in which it may exist. So far as concerns chrome mines, it would be futile to argue the position of an unknown pocket from the basis of any known ore."

From the above extracts and quotations it will be seen that the discouraging features of New South Wales chrome mining are not peculiar to this country; moreover, they serve to emphasise the views expressed in my second report on the Gandagai-Tumut chrome field†:—"Chrome mining in the districts in question has now been advanced to a stage which enables a fairly clear opinion to be formed of the nature and mode of occurrence of the deposits; and the experience of the past year teaches that they in no way differ from those of other countries which have been described as "pockety" and "bunchy," "irregular" and "uncertain." Therefore it seems imperative, if the chrome industry is to be advanced and maintained as a profitable commercial undertaking, that systematic prospecting must be kept well ahead, not only of actual winning, but also of actual discovery, so that new finds may be made available as the old give out, and thus prevent frequent cessation of work.

With resolute grasping of the fact of comparatively small but numerous and widespread deposits, coupled with systematic prospecting and proving, careful blending of ores and uniformity of grade, and by saving and concentration of smalls where practicable, there can be no doubt that the chrome industry of the Colony will be maintained on a vigorous and profitable scale.

In prospecting, it will be wise not to confine the search to surface outcrops of deposits, but to extend it to alluvial deposits; for, as already mentioned, commercial accumulations of chromite detritus are worked both in Russia and New Caledonia. In passing along the serpentine belt between Tumut and Mount Lightning, chromite rubble was frequently observed on grassless patches and in small rivulets on the slopes of the ridges. Advantage should be taken of these indications to trace by loaming—washing portions of soil—the source of the liberated particles; for though they may in some instances be derived from serpentine containing the mineral sparingly distributed through the mass (as chromite is always present in small proportion in serpentine), yet there is always reasonable prospect of it being shed from segregated masses, which at the present time are obscured by soil.

An instance of natural concentration of disseminated particles liberated by decomposition is furnished on a very small scale at Port Macquarie, where the now coherent grains form small patches assaying 48 per cent. of chromium sesquioxide.

Dressing and Concentration of Chromite.

The necessity of concentration is a question which is forcing itself on the attention of those interested in chrome mining. In California, where much of the ore at present accessible is of low grade, concentration has already been adopted; for, as pointed out in the valuable work already freely quoted ("Mineral Industry"), "the future of the chrome industry in California seems to depend upon more careful dressing of the ore, either by hand or mechanically." There can be no question that, apart from utilising deposits of low-grade ores in this way, the great market desideratum, viz., uniformity of grade, would be secured by dressing and concentration.

Where the ore is rich the usual practice of cobbing and hand-picking is sufficient to secure a high grade, but generally the richest ores are the most friable; hence considerable loss is entailed as smalls during the present

† Ann. Rept. Dept. Mines and Agric., N.S. Wales, for 1895, p. 128.

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process of mining and hand-dressing. The rich fragments which thus become mixed with the waste could be recovered by concentrating machinery. Hard, compact ore of low grade, in which the impurities are finely and intimately mixed, may not prove as amenable to concentrating treatment as comparatively lower-grade ores roughly mixed with serpentinous impurities. The latter, in cases where the serpentine has decomposed into magnesium clays, would probably afford special facilities for concentration. The hard ore in question might be utilised in two ways: after coarsely crushing and washing it might be mixed in carefully ascertained proportion with the rich concentrates to ensure an uniform grade of good quality; or it might be made available for furnace lining if the market rate afforded a margin of profit.

Touching the method of concentration, the following description of a plant running in California is valuable as a guide*:—"One of the chrome dressing works now in active operation in California is equipped as follows:—Rock-breaker, 6-ft. Huntingdon mill, and four Woodbury vanners with corrugated belts, together with settling tanks, drying floors, and the usual driving machinery, &c. The plant, which is capable of turning out from 20 to 25 tons of dry concentrates per twenty-four hours, cost about 12,000 dollars (£2,400). The process is carried out as follows:—The ore is crushed by the breaker and the Huntingdon mill so as to pass a 40-mesh sieve. The pulp is separated on the Woodbury vanners. The concentrates are collected in settling tanks, whence they are removed to the drying floors, and finally packed for shipment in strong jute bags."

The fuel used is wood. The crude ore does not cost more than 7 dollars (28s.) per ton for best grades, delivered at the mill.

The result of a month's run of the above mill is stated to have been 700 tons (2,000 lb. per ton) of 50 per cent. concentrates, which at the then market rates (1893) yielded a profit of 3 dollars (12s. 6d.) per ton, and 1 dollar (4s. 2d.) per ton for each 1 per cent. above 50 per cent. produced.

The following analyses give the results of the concentration of Californian crude ore†:—

	Crude Ore.	Concentrates.
Sesquioxide of chromium	43·70	52·86
Protoxide of iron	14·80	15·45
Alumina	15·96	11·59
Magnesia	16·49	16·26
Silica	7·96	3·00
Lime	·66	·76
Water	·49	·10
	100·06	100·02

Owing to the varying percentages of sesquioxide of chromium contained in chromite, it is recommended that preliminary panning or hand-jigging tests, with careful analysis of results, should first be made to ascertain the suitability of the various ores for treatment on a large scale of concentration.

With regard to concentration of New South Wales low-grade chromite and smalls resulting from mining and hand-dressing, both the Gundagai-Tumut and Clarence River deposits appear to offer fair fields for practical tests. At Mount Lightning, Adjungbilly, and Brungle Creeks, a plentiful water supply is available for such operations; but looking at the question in a larger light than individual interests, and having regard to the scattered occurrence of the deposits and the comparatively limited amounts of material

* Mineral Industry, 1893, ii, pp. 153–4. † Mineral Industry, 1893, ii, p. 153.

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available at any one mine or group of mines, there can be no question that the establishment of a central dressing and concentrating plant on the Murrumbidgee River—(say) at Gundagai, the present railway terminus in the district—would best serve the interests of the whole field. Low-grade ores, seconds, and smalls, could be disposed of to such an establishment on bulk assay values.

Uses of Chromic Iron Ore.

Before discussing the uses of chromite it will be useful to briefly note its physical characteristics and chemical composition. The metal chromium (of which chromite is an oxide), according to R. A. Hadfield,* has an atomic weight of 52·40, and a specific gravity of 6·8–7·3, with a high melting point not yet determined.

Chromium is used in the metallic state only in making chrome steel, and even in this instance it is used as ferro-chromium. Quite recently M. Henri Moissan† has demonstrated the possibility of manufacturing pure chromium and tungsten in commercial quantities. His latest method is to take a carbon pipe filled with the metallic oxide mixed with carbon, inclining it, and subjecting it to the electric current; the metal contaminated with carbon readily flows off as a result of the reaction. Two carbides of chromium have been identified. The carbides are purified by remelting with lime.

Chrome steel is used chiefly in the manufacture of armour plates and armour-piercing projectiles, for shoes and dies in stamper batteries, and for burglar-proof safes and edge tools. Professor Garrison states that the "extreme hardness of the chromium steel face is dependent upon the content of carbon, whose action is intensified by the presence of the chromium, and is only developed after the steel has passed through a system of hardening. This tempering consists essentially in heating the plate to a red heat, and quenching it with sprays of ice water."‡ Sir Frederick A. Abel, in his presidential address before the British Association for the Advancement of Science, Leeds, 1890, stated that "chrome steel has for some time been a formidable rival of the very highest qualities of carbon steel produced for cutting tools, and of the valuable tungsten steel. The great hardness, high tenacity, and exceeding closeness of structure possessed by suitably tempered steel containing not more than from 0·8 to 1 per cent. of carbon, renders this material invaluable for war purposes. Cast projectiles, when suitably tempered, have penetrated compound steel and iron plates over 9 inches in thickness, such as are used upon armoured ships of war, without even sustaining an important change of form."

The presence of a small percentage of chromium in gun-metal is also likely to prove beneficial. Chromium is used in the production of first quality steel rails for railway purposes. Steel with 1 to 1·5 per cent. of carbon and from 2·5 to 4 per cent. of chromium is stated to be so hard that it cannot be worked with the ordinary hardened tools; consequently it has been called into requisition for the construction of burglar-proof safes. For this purpose it is welded and rolled with iron plates.

Chromite is the most common ore of chromium. Its composition, according to Dana, is—chromium sesquioxide, 68·0; iron protoxide, 32·0=100. Specific gravity, 4·32 to 4·57; hardness, 5·5; colour between iron-black and brownish-black, generally exhibiting emerald-green encrustations on smooth semi-conchoidal faces; lustre, sub-metallic to metallic, sometimes feebly magnetic.

Tests.—Before blowpipe in oxidising flame, infusible; in reducing flame, slightly rounded on the edges, and becomes magnetic.

* Journal Iron and Steel Institute, 1892, ii, p. 53. † Engineering and Mining Journal, Nov. 6th, 1897, p. 550.
‡ Ann. Rept. U.S. Geol. Survey, 1894-95, xvi, pt. iii, pp. 610-14.

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With borax and salt of phosphorus, gives beads which while hot show only reaction for iron, but on cooling become chrome-green. Not acted on by acids, but decomposed by fusion with potassium or sodium bisulphate.

Chromite is reported as not uncommon in meteoric iron.

Other ores of chromium occur, the chief of which is crocoisite—chromate of lead—in which the metal was first discovered.

Serpentine, in which the chrome deposits occur, owes its colour to chromium salts. The beautiful colour of the emerald and of ouvarovite (chrome-garnet) is due to the presence of chromium, and probably also that of the ruby and sapphire; for it has been demonstrated that if the formation of crystallised alumina is accomplished in the presence of chromium compounds, crystals having the colours of ruby and sapphire, as well as their composition, may be produced.*

The other varieties of chromium ores are of mineralogical interest only, and call for no special mention in this paper, which is concerned with the economic ore alone.

Chromite, or chromic iron ore, is used in the arts for the manufacture of potassium and sodium bichromates, for the preparation of basic furnace hearths, and for reduction to ferro-chromium for the production of chrome steel. By far the most part of the mineral produced is employed for the first purpose, for which only that of high grade can be economically used; while for furnace hearths, and for manufacture of ferro-chromium, ore of lower grade suffices. ("Mineral Industry," vol. ii, 1893, p. 158.)

Chromite is coming largely into use as a refractory lining for basic furnaces. The latest particulars available of its use in this direction are given in the last volume of "Mineral Industry,"† from which the following extracts are taken:—"At present the mineral is employed in reverberatory copper-smelting furnaces, and in open hearth steel furnaces, in both with very satisfactory results. Concerning the former, Herbert Lang writes‡: 'The Selby Smelting and Lead Company has used it quite extensively in the matting reverberatories at Vallejo Junction, California. The hearth is composed of large fragments of chrome ore, with the interstices well filled with smaller pieces, and the material is built up around the sides to the slag line. The protection is such that fettling is almost done away with; in fact, they have not to fettle but once a week or so. The chrome ore is acted on but slightly, if at all.' Alfred von der Rupp, Superintendent of the Works, states§ 'that the life of the furnace is more than doubled by the use of chromite.'"

In the "Mineral Industry," 1893, vol. ii, it is stated that chromite has been used instead of magnesite and dolomite in basic furnace hearths, the method of preparation of which is given as follows:—"In preparing basic furnaces with chromite linings, all parts of the walls with which the metal bath and slags come in contact are laid with pieces of chromite, cemented with a mortar consisting of two parts (by volume) of finely ground chromite, and one part of lime, burned as free from silica as possible. The hearth is made of stamped chromite ore, mixed with same kind of mortar. The ore should be as rich as possible in chromic acid, containing from 40 to 45 per cent."

In Vol. ii, 1895, p. 506, of the "Journal of the Iron and Steel Institute," reference is made to an article in "L'Echo des Mines," vol. xxi, page 548, as follows:—"According to P. Speier, chrome ore linings for reverberatory

* Precious Stones and their Artificial Production; by Prof. J. W. Judd, C.B., LL.D., F.R.S.—Roy. Coll. of Science Magazine, No. 74, vol. viii, pt. 9, p. 263.
† The Mineral Industry, &c., 1896, vol. v, pp. 120-3.
‡ Engineering and Mining Journal, January 23rd, 1897, p. 89.
§ Mining and Scientific Press, Sept. 26th, 1896, p. 257.

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furnaces have been successfully adopted in French, German, and Russian steel works. The bottom and walls of the furnace are lined with chrome ore in large blocks, united by a cement formed by two parts of chrome ore finely ground, and one part of lime, as free from silica as possible. . . . . The iron chromate is decomposed only under the influence exerted by the reagents and oxidising alkaline substances. Heat alone is insufficient to decompose chromate of iron, which may float in a bath of molten steel covered with basic slag without dissolving. One of the principal conditions of success in the employment of the chrome ore lining consists in carefully picking the pieces of ore used, which should be of uniform composition; and the best composition of ore used for lining reverberatory furnaces is found to be from 36 to 40 per cent. of chromic oxide, 18 to 22 per cent. of clay, 9 to 10 per cent. of magnesia, and at most 5 per cent. of silica."

Messrs. G. R. Blackwell, Sons, & Co., of Liverpool, England, are quoted for the statement that chrome ore had been used by steel manufacturers in Lancashire and Yorkshire for about fifteen years. They also remark that it is not necessary to make the chrome ore into bricks, a better method being to crush it to pea size, mix with tar, and line the furnace as if with mortar. The tar burns away, leaving a solid lining of chrome ore, which has been found to give satisfactory results.

The consumption of chrome ore in open hearth basic furnaces in the United States amounts to about 1,800 to 2,000 tons annually, according to the publication quoted ("Mineral Industry"), the Pittsburg supply being for the most part from the Province of Quebec. The requirement is for an ore of not less than 45 per cent. chromium sesquioxide, but the shipments are reported to rarely average so high. The ore is used in lump form for patching the sides of the basic lined furnaces, and is found far more convenient and durable than a slurry of dolomite.

According to the same authority, very hard and lasting chrome bricks are manufactured at Pittsburg for use as a neutral parting between the basic hearth and silica roof.

In connection with the rapidly increasing use of chromite as a refractory furnace lining, the comparatively low grade of material suitable for this purpose should have an important bearing in the near future on the local chrome mining industry, for increasing demand the natural correlative of increasing use is almost certain to give a remunerative value to ore at present below the minimum market grade, deposits of which are already known to exist in the local chrome fields.

Buyers still stipulate for high grades of 50 per cent., or more; probably 47 per cent. is about the lowest local grade for which a price would be quoted at the present time. It will, however, be noted in the quotations and extracts embodied in this paper that the stipulated grade of chrome ore for furnace lining at Pittsburg, U.S., is 45 per cent., and even this comparatively low grade percentage is reported to be rarely reached. The average percentage of chromic-acid in furnace lining may be taken as about 40 to 45. In chrome steel manufacture, or more correctly in the preparation of its preliminary stage of ferro-chromium, low grade ores of the above character are reported to be suitable.

Whilst fair supplies of rich ore are procurable from Asia Minor, Greece, and New Caledonia at about 75s. per ton (f.o.b.) for 50 per cent. ore, and 2s. per unit in excess, as has recently been quoted in a letter from Cologne to the Department of Mines and Agriculture in this Colony*, much lower than fairly proportional values will rule for low grades; still there is reasonable

* From F. E. Clotten, 136, High-street, Cologne, Germany.

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hope that increased consumption in the latest sphere of usefulness will correspondingly increase the value of lower grades, and thus render remunerative local deposits of this character known to exist within easy reach of railway carriage.

Railway concessions for transport of crude ores to seaboard have been steadily increasing until the rate per ton per mile has reached a nominal figure. Shipping freights can also be arranged for them at exceptionally low rates owing to the effective stiffening they afford to wool ships and other carriers of bulky cargo.

Attention is also directed to another bearing which the successful use of chromite as a refractory furnace lining may have on local industry, viz., the possibility of local consumption in connection with copper and matting furnaces, to say nothing of the iron smelting furnaces of the—it is hoped—near future. Doubling the life of a furnace and reducing fettling to a minimum—as proved in other countries—by the use of chromite lining, should induce practical tests in this Colony.

The chief use of chromite at the present time is in the preparation of chemical salts for use in the arts, in painting, calico printing, dyeing, and tanning. Chrome pigments embrace various shades of red, yellow, green, buff, and black. Green oxide of chromium is used extensively as an enamel colour for porcelain.

A new use for chromite is reported from France, where a compound known as *Silichromite* is manufactured. According to "Mineral Industry" (vol. v, 1896, p. 123) "it is an extremely hard, crystallized substance, but easy to pulverize, and is used for moulding and polishing purposes. It is prepared by treating chrome ore, sand, and coal, in an electric furnace, wherein a molten mass, in which chromium silicate predominates, is obtained."

Register of Chromite Occurrences in New South Wales, with Notes and Descriptions.

*Adjungbilly Creek, Parish Darbalara, County Buccleugh.**—On the south side of Mount Lightning, close to the Adjungbilly Creek, Messrs. Carroll and Gillespie were working on tribute an area on Mr. Quilter's property, known as the Mount Mary Mine. At the time of my inspection in 1895, about 400 tons had been despatched, averaging, according to the tributors' statement, from 48 to 49 per cent.

The main deposit was being worked by means of an open cut about 50 feet long, and 20 to 30 feet deep. The ore exposed under foot was solid, and about 7 feet in thickness, whilst a wedge of ore in the upper workings was left standing about 12 feet high and 10 feet thick.

Several smaller bunches were exposed by shallow cuts and trenches high up the slope of the mount.

The most important of the new finds was situated near the top of the mount, where a solid bunch about 10 feet by 4 feet outcropped above the soil.

On the south side of Adjungbilly Creek, on the continuation of the serpentine ridge, Welsh's mine is situated. The only known deposit in this mine was exhausted for a yield of about 220 tons.

Angular Creek, County Murchison.—Chrome has been reported from this locality, but no particulars are known.

Attunga and Manilla—Between these localities a serpentine belt extends in N.N.W. direction. Several chrome deposits have been reported in it by Mr. C. S. M'Glew; but, so far as his prospecting extended, none were of sufficient size to induce mining for export.

* J. E. Carne, Ann. Rept. Dept. Mines and Agric. for 1895, p. 126.

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Armidale.—Samples submitted for assay in 1884 and 1886 from the Armidale district yielded 38·5 and 43 per cent. respectively.

Barraba.—Chromite from this district, assayed in 1888 and 1895, yielded 40 to 44 per cent.

Bendemeer.—Chromite, assaying 38·5, submitted in 1884.

Berthong Run, near Wallendbeen.—Mr. Geological Surveyor Jaquet has described the Berthong chrome deposits as follows:—"Chromite has recently been discovered upon Berthong Run, but nothing has yet been done in the way of proving the extent of the deposits. In the bed of Berthong Creek a shallow trench of 5 feet long and 2 feet broad has been cut through a mass of this mineral. Chrome ore has also been found in a shallow trench put down upon the banks of a tributary of Berthong Creek. In the vicinity of the discoveries, and over a large portion of the serpentine zone, the bed-rock is hidden by a shallow alluvial deposit, and it will be necessary for prospectors to find the ore bodies below."*

Samples forwarded from the above-described deposits yielded from 39·5 to 54·04 per cent.

Bingara.—Chromic iron deposits have been noted at Spring Creek, about 3 miles south-easterly from Bingara, by Geological Surveyor David, who reported that the serpentine in which they occur "forms an eruptive dyke from 3 to 5 chains wide, striking either north-westerly or northerly. Segregated masses of chrome iron are observable at intervals in the serpentine,"† and one bunch is stated to measure about 7 feet by 6 feet. Two assays are recorded from the Bingara district, viz., 40·87 and 41·21, the localities being 12 and 14 miles south of Bingara.

Bowling Alley Point, near Nundle, Peel River.—As already mentioned the deposits of this locality were the first opened in the Colony—100 tons being mined in 1882.

The late Government Geologist, Mr. C. S. Wilkinson, F.G.S., &c., in one of his reports states that "on a high range about 1 mile north-east from Bowling Alley Point occurs a lode of almost pure chromite of variable thickness. In one place, at the junction of diorite and serpentine, it crops out on the surface 12 feet wide."‡

Professor Liversidge states that "the outcrop from which this was taken—(samples of chrome under description J.E.C.)—is about 700 feet above Bowling Alley Point, and the apparent thickness of the vein is in one part some 40 odd feet; one huge block of the mineral lying loose on the surface measures 12 feet long by 6 feet high, and 5 feet wide." A specimen from this locality is reported by the same author to have contained 64·72 per cent. chromium sesquioxide, and 21·11 per cent. iron protoxide.§ Other assays in 1892 are recorded varying from 37·42 to 43·50 per cent.

Brawlin, from foot of Cowong Range, 7 miles south-east.—A sample forwarded for assay, bearing the above locality, yielded 31·13 per cent.

Brungle Creek, Parish Wyangle County Buccleugh.—¶The Emu and Mount Miller Mines occur on either side of this creek, near the crossing of the Tumut-Tomorrowmah Road. The serpentine is here deeply intersected by the creek and its tributaries. The Emu Mine at the time of inspection consisted of two bunches of chromite, one rather superficial, the other of better promise as regards size, but not as regards quality. Abundant water supply in close proximity to both the mines mentioned should afford the best means of ensuring a high grade product for export.

Mount Miller Mine is situated high upon the range on the opposite side of the creek. The deposits here are very small at surface. A sample from the outcrop yielded 48·13 per cent.

Assays from this locality are recorded from 32·16 to 52·54 per cent.

Clarence District.—See Gordonbrook.

Coolac.—See Wrights and Vulcan Mine, Mooney Mooney.

Cootamundra.—Assays are recorded of samples purporting to come from this locality—but which may be either Berthong or Coolac—from 45·75 to 57·82 per cent.

Copmanhurst.—Probably identical with Gordonbrook. Assays recorded from 40·71 to 45·45 per cent.

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* Ann. Rept. Dept. Mines and Agric. for 1895, pp. 179 and 180.
† Ann. Rept. Dept. Mines and Agric. for 1891, p. 235.
‡ Ann. Rept. Dept. Mines for 1885, p. 135. § Liversidge, Minerals of New South Wales, 1888, p. 106.
‖ Ibid. ¶ J. E. Carne, Ann. Rept. Dept. Mines and Agric. for 1895, p. 127.

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Darbalara Parish, County Buccleugh.—See Quilters's Mines.

Emu Mine.—See Brungle Creek.

Eurongilly.—On Mr. Keogh's private land a small bunch of low grade chromite was noted, which had been broken from a loose block found in the soil which here is deep. The country consists of talcose slate. Assays are recorded from 40·9 to 41·38 per cent.

Gordonbrook, Clarence River.—Mr. Geological Surveyor David reported on the occurrence of chromite in this locality in 1891. They occur in the parish of Pucka, about 30 miles north-west from Grafton, at Oaky and Fine Flour Creeks.

"The deposits of chomite in this neighbourhood form two principal groups. . . They both occur in serpentine at a short distance from the edge of the Clarence Series. . . Besides these two formations a third is developed, which may be described as a fine-grained, greenish-black rock, slightly crystalline, and, probably, a highly altered rock, which might be termed epidiorite. . . . This rock appears to have been intruded by the serpentine, and the deposits of chromite marked A on the plans herewith occur chiefly along the junction line of this rock with the serpentine."*

In connection with the first group (A) in Portion 7, Parish Pucka, Mr. David measured the two larger bunches as 12 feet x 12 feet and 24 feet x 18 feet. In the latter the chromite was a good deal mixed with serpentine, and would require dressing to render it marketable.

Deposit B is reported as forming a bluff on the left bank of Oakey Creek, about 2 miles north-westerly from the first group. The second group consists of two bunches—the main one about 90 feet x 36 feet at its maximum width. The quality is reported as superior to that of A group.

At the time of inspection the above deposits were not proved beyond a few feet except in the main deposit of the second group (B), of which a natural section is available down to 20 feet in the creek channel.

Mr. David regarded the deposits as lens-shaped bodies, the vertical extension of which, probably, equals the horizontal. Calculating on the basis of these dimensions, he estimated that the known Gordonbrook deposits would yield approximately about 20,000 tons of chrome ore to a depth of 90 feet from surface.

Samples selected at the time of inspection yielded from 40·25 to 55·27 per cent. Others by Mr. W. A. Dixon, F.C.S., F.I.C., were quoted in the report from 39·7 to 48·61 per cent. Earlier assays (in 1886) are from 28·44 to 47·70.

Two attempts to open these deposits have been made in 1891 and 1895, but so far unsuccessfully. Perhaps cost of carriage is one of the chief reasons for non-success. From the mines to Copmanhurst, the nearest point of available water carriage on the Clarence River, a distance of about 24 miles, has to be negotiated with teams, part of which is over a rough road.

Gundagai District.—See Mooney Mooney, Vulcan, Quilter's Adjungbilly, and Kangaroo Mine.

Gwydir River.—Chromite is reported from the Gwydir River and its tributaries (see Bingara).

Gulgong (?).—A sample of rich chromite is reported from this locality, but no analysis or particulars are given.†

Grenfell.—From near Grenfell a sample yielding 43·22 per cent. is recorded.

Harden, County of.—See Mooney Mooney.

Houlahan, Parish of, County Clarendon.—Chromite from this locality yielded 40·71 per cent.

Ironbarks and Barraba.—Chromite from the serpentine of this district has been assayed for a yield of 46·45 per cent.

Ironbarks, between Ironbarks and Mudgee.—Chromite has been reported from between the places mentioned, but there are no particulars on record.

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* Ann. Rept. Dept. Mines and Agric. for 1891, p. 218.
† Ann. Rept. Dept. Mines for 1877, p. 211.

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Kangaroo Mountain, Kangaroo Mine, Parish Wagara, County Buccleugh.*—The Kangaroo Mine is situated in portion 128. It was opened in 1894 by Mr. M. Constable, under agreement with owner of the land, Mr. Robert Owen.

This deposit constitutes one of the most important of the chrome-field, both as regards extent and quality. At the time of inspection in February, 1895, the output was averaging about 100 tons per week, about 1,200 tons having been dispatched to that date.

Down to 30 feet the main open workings averaged about 75 feet x 25 feet x 30 feet. At this point the dangerous open work system of mining was abandoned in favour of a safer method of shafts and levels.

For about 200 feet the ore body was exposed by open cuts. At surface the solid chromite was narrow, but opened to about 18 feet in the widest part. In the open workings, at 30 feet level, the chromite exposed measured about 54 feet by a width of 4 feet.

The quality of the ore proved consistently good, the lowest average in account sales of 1,230 tons dispatched to the date mentioned was 53 per cent., and the highest 57 per cent. of chromium sesquioxide.

In addition to the Kangaroo Mine, about twelve other smaller deposits were discovered which yielded about 75 tons of marketable ore. Other pockets were known at the same time, but had not been opened.

Keefe's Mine,† between Brungle and Bumbolee Creeks, County Buccleugh.—At the time of inspection (February, 1895), little work had been done at this site, which is on private property. A small chromite bunch or pocket, about 6 feet long by 2 ft. 6 in. wide, had been opened for a few feet only. Most of the ore was mixed with country, and required dressing. Other deposits were reported on this property, and latterly more attention has been given them. Distance of team carriage, however, is reported to have prevented profitable mining being maintained at the present time.

King, County of, near Yass.—Chromite has been noted in this county, but no particulars are available.

Manning River, Upper.—A sample purporting to come from this locality has been assayed in the Departmental Laboratory for a yield of 46·19 per cent.

M'Inerny's Mine,‡ near Bumbolee Creek, 8 miles from Tumut, situated near the south-west corner of Portion 351, *Parish Mundongo, County Buccleugh.*—This site was also inspected in February, 1895. A few small bunches were then being prospected, but the quality of the ore was inferior. This mine was the furthest southerly in the serpentine belt at the date mentioned, the distance from the Gundagai railway station being about 30 miles.

Molong, 15 miles west.—A sample of chromite bearing this inscription was assayed for 24·08 per cent.

Moonbi, 12 and 15 miles from.—Numerous samples have been forwarded from this District. Assays are recorded from 39·21 to 43·30 per cent.

Mooney Mooney.—See Wright's and Vulcan Mine.

Mount Lightning.—See Quilter's and Mount Mary Mines, and Adjungbilly.

Mount Mary Mine.—See Adjungbilly.

Mount Miller Mine.—See Brungle Creek.

Murrumburrah.—Chromite reported as coming from this district yielded 44·40 per cent.

Nundle.—See Bowling Alley Point.

Oaky Creek—See Gordonbrook.

Paling Yard and Dry Diggings, (between).—Chromite sent for assay from this locality yielded 40·67 per cent.

Port Macquarie.—From the serpentine of Port Macquarie samples of coherent chrome iron sand have been received recently, which yielded 48·24 per cent. chromium sesquioxides and 1·29 per cent. of cobalt protoxide. No solid chromite pockets have yet been discovered in the neighbourhood, and the mode of occurrences of the compact sand points to the natural concentration of small disseminated particles of chromite liberated by weathering and decomposition of the serpentine. Magnetic iron oxide occurs at Port Macquarie under similar conditions.

Pucka.—See Gordon-brook.

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* J. E. Carne, Ann. Rept. Dept. Mines and Agric. for 1895, p. 126. † *Ibid*, p. 127.
‡ J. E. Carne, Ann. Rept. Dept. Mines and Agric. for 1895, p. 127.

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*Quilter's Mines**.—Of the six deposits of chromite described in my first report*, as occurring on Mr. John Quilter's property at Mount Lightning, three had been opened by the date of my second visit in February, 1895, and 1,100 tons of ore despatched mainly from two of the deposits. Both the latter presented very small outcrops. The open cut system had been adopted in winning the ore, but at 20 feet it had to be abandoned in favour of safer methods. Two of the largest deposits are unfortunately of very moderate grade, and hence have so far been little worked. No doubt, advantage will yet be taken of them when more systematic grading and dressing is adopted. Four consignments, aggregating 800 tons, from the deposits opened to the date above quoted, yielded from 49·8 to 56·5 per cent. of sesquioxide of chromium. By careful blending a considerable quantity of the abundant lower grade ore could be worked in with the first grade, and a uniform percentage of, say, 50 per cent. maintained.

The ore in this mine was conveyed by gravity from the mountain on a wire rope to the opposite side of the Murrumbidgee River, the bags of ore being suspended by hooks with running blocks.

Shoalhaven.—A sample of chromite, assaying 49·55 per cent., was received as coming from the above locality, but its correctness is very doubtful.

Stony Batta, County Hardinge.—Chromite reported. No particulars.

Tamworth District.—From 20 miles north, 26 miles north-west at Hall's Creek, and from Manilla Range, samples of chromite have been received, yielding from 40·41 to 46·59 per cent.

Tumut District.—See Darbalara, Wagara, Brungle, and Wiangle Parishes, County Bucclengh.

Uralla.—

*Vulcan Mine**, *Mooney Mooney Range, 4 miles north-easterly of Coolac Railway Station.*—As already stated, the group of deposits at the site of this mine were the first opened in the Gundagai district under the name of Wright's Mine. At the time of my first inspection in 1892†, a little surface prospecting or uncovering had been done. The largest deposit thus exposed was about 63 feet by 12 feet at the greatest width, to a depth of 10 feet. The average width of chromite was about 7 feet. About 2 chains further down the slope of the hill another deposit, partly exposed by shallow openings, measured 45 feet by 5 feet. Selected samples from the two outcrops yielded 47·68 and 48·00 per cent. Cr_2O_3.

Estimates of the probable quantity of ore available in these deposits, based on the supposition that they were lens-shaped, and that the vertical extension might be assumed to be equal to about half the horizontal (owing to weathering of the exposed surface) tallied very closely with the actual amount won during mining operations. At the time of my second visit in February, 1895, about 1,200 tons had been raised and dispatched; and, judging from the appearance of the dangerous open workings—which were just then being abandoned on account of risk—the total output would be in the neighbourhood of the former estimate, viz., 2,250 tons.

Wagara Parish, County Bucclengh.—See Kangaroo Mine.

Walcha District.—A sample of chromite submitted from this district assayed 48·26 per cent.

Wallendbeen.—See Berthong.

Welch's Mine.‡—In Portion 173. On the west side of the continuation of the serpentine range, south of Adjungbilly Creek, Messrs. Welch and Springthorpe extracted 220 tons from a deposit, which gave out abruptly, and was abandoned.

Wright's Mine.—See Vulcan.

Wyalong (near).—A sample submitted for assay purported to be from this district, but the information is doubtful. It assayed 37·35 per cent.

Wyangle (Parish of).—See Brungle Creek.

Young District.—Chrome occurs about 20 miles from Young. A little attention has been given to it, and a number of assays made, ranging from 42·46 to 48·35 per cent.

Yulgilbar, Clarence River.—Chromite has been examined which was reported to have come from the ranges between Solferino and the local Cinnabar Mine; and as serpentine occurs in this locality, the report is probably correct.

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* J. E. Carne, Ann. Rept. Dept. Mines and Agric. for 1892, p. 154. J.E.C., *Ibid*, 1895, p. 125.
† J. E. Carne, Ann. Rept. Dept. Mines and Agric. for 1892, pp. 153-9.
‡ J. E. Carne, Ann. Rept. Dept. Mines and Agric. for 1895, p. 126.

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DEPARTMENT OF MINES AND AGRICULTURE.

GEOLOGICAL SURVEY.

E. F. PITTMAN, A.R.S.M., Government Geologist.

MINERAL RESOURCES.

No. 2.

NOTES

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WITH A

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Notes on the Occurrence of Tungsten Ores in New South Wales;

WITH A

REGISTER OF LOCALITIES.

By J. E. CARNE, F.G.S.,
Geological Surveyor.

Reviewing our knowledge of the local occurrences, it must be admitted that no payable deposits have yet been discovered, notwithstanding the stir caused by the sudden large advance in values of tungsten ores about the year 1890, although numerous fresh occurrences have been noted, and previously known ones more or less superficially explored.

Judging from the known deposits of tungsten ores in this Colony, and from the extremely limited outputs recorded in the statistical returns of countries producing them, notwithstanding the constant demand, it would appear that the ores of this metal are sparsely distributed in nature.

The chief supplies appear to be drawn from Cornwall (England), Austria-Hungary, Germany, and Saxony. Texas and Northern Mexico are reported this year to be offering unusually large quantities from recently-opened mines.*

The following outputs, recorded from the first-mentioned countries, are taken from "Mineral Industry," 1896†:—

1891–5.	United Kingdom ...	289 tons	(returned marked *nil* for 1894–5).
1891–5.	Austria-Hungary...	247 „	
1891–5.	Saxony	226 „	
1891–4.	Germany	208 „	(mixed Wolfram and Uranium ores).

In the "Mineral Industry of the United Kingdom, 1895, Second Annual Report," Portugal and Spain are also recorded as producers of tungsten ores to the extent of 19 tons and 14 tons, respectively, in 1894.

The above quotations serve to exemplify the very restricted world-production of tungsten ores, and explain the reason of rapid advance in value as fresh uses are discovered for the metal or its salts.

Prior to 1890 the market value of tungsten ores did not exceed about £12 per ton. In that year Messrs. Sternberg and Deutsch, of Martinikenfelde, *via* Berlin, made personal inquiry for wolfram in the New South Wales Court at the London Mining Exhibition, and offered £30 per ton for

* Extract from an official letter from F. E. Clotten, 136, High-street, Cologne, Germany.
† The Mineral Industry: Its Statistics, Technology, and Trade, 1896, v, pp. 749, 771, 776, 819.

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ore containing 70 per cent. tungstic acid, delivered in Berlin. This first intimation of rapid advance in value was announced in the Colony through the Department of Mines, and resulted in considerable activity in prospecting for this mineral. Prices have receded since that date. The present value for 70 per cent. ore may be accepted as about £20 per ton, bagged, free on board, at Sydney, with an advance of 5s. 3d. per unit above 70 per cent. These quotations are from Mr. Clotten's letter already referred to. The English value for production in 1893 equalled about £19 per ton.

The high minimum market grade—viz., 70 per cent. tungstic acid—requires ore entirely separated from gangue; indeed, some wolfram ore, to all appearances clean, falls below this standard. Dressing to standard by cobbing and hand-picking is not a difficult matter when the ore is in fairly large clean bunches; but in the case of small particles or crystals distributed through the gangue, which is usually quartz, separation would be almost economically impossible, under the local conditions of mining and dressing, owing to the heavy loss entailed by the brittleness of wolfram (which is the chief ore), arising from its facile cleavage into extremely fine plates. The reduction of the quartz gangue by stampers or rolls to the requisite fineness to free the ore particles would slime most of the wolfram and necessitate an extensive recovery plant. If lower grade ore was saleable, possibly miners could obtain more remunerative returns from proportionately lower selling values.

Until recent years the principal use of tungsten was in the preparation of acid salts for rendering coloured cotton goods "fast," or washable, and linen and cotton theatrical or other properties non-inflammable, and in the manufacture of stained and other papers, &c.

Its chief value, however, at the present time is as an alloy in the production of certain classes of steel for artillery and tool purposes. There is, however, considerable diversity of opinion amongst authorities as to the special qualities or merits of tungsten steel, some affirming and others denying its brittleness and hardness.

Professor F. L. Garrison discusses this question in an interesting article on "Alloys of Iron and Tungsten," * and quotes Metcalf, from the "Transactions Am. Soc. C.E.," Vol. XXVII, pp. 394-5, and H. M. Howe's "Metallurgy of Steel," p. 82, for the following statements:—"It is popularly believed that tungsten renders iron very hard, and in support of this is the fact that there are many brands of so-called self-hardening steel on the market—that is, steel which does not require to be rapidly cooled in order to become hard. Nevertheless, this belief is erroneous; for if a steel be chosen not excessively high in manganese and carbon, as all the self-hardening specimens are, then no amount of tungsten will make it file-hard if allowed to cool spontaneously in the air. The true function of this element is to delay the rate of change of carbon when either going in or out of solution. . . . . Tungsten steel is neither so hard nor so strong as plain carbon steel; hence there is no advantage in using it except for certain purposes."

Professor Garrison remarks that Metcalf has also referred to tungsten in steel as acting merely as a vehicle in enabling the carbon to carry the "temper" or "hardness." He further observes that this peculiarity is only developed in the presence of manganese.

Howe states that "the hardness of tungsten steel is not impared by heat, and as a consequence may be driven much faster than carbon steel when used as machine cutting tools."

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* Ann. Rept. U. S. Geol. Survey, 1894-5, xvii, pt. 3, pp. 615-623.

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"Tungsten steel appears chiefly adapted for cutting tools of lathers and planers."*

"When forged red-hot and slowly cooled, tungsten steel is reported to possess an extraordinary degree of hardness, which, however, gives way to softness when plunged red-hot into cold water, quite contrary to most other species of steel."†

E. Fuchs and L. De Launay state that "Tungsten has for some time been used to a considerable extent in the manufacture of steel, particularly for artillery, and this use is restricted only by the rarity of the metal itself."

"In a series of experiments made by Captain Caron, the addition of tungsten to cast-iron (⅛ to 1 per cent.) increased the hardness and the tenacity of of the metal in proportion to the weight of the tungsten added. . . . But it is especially in the case of steel that tungsten in very small proportions increases the hardness and tenacity."

"This influence of tungsten on steel and iron tends to prove that it neutralises the contained phosphorus, sulphur, and arsenic, combining with them chemically. In cast iron it is reduced at the expense of the carbon, and adds, more or less, to the metal the character of steel."‡

Tungsten ores are most frequently associated with tin and bismuth ores, and, as before stated, the principal supplies are drawn from tin workings. In fact, in some countries and provinces—Saxony, for instance—the waste from ancient tin-dressing floors has been carefully worked over for the discarded wolfram of earlier mining days. In others wolfram has become the most important product of previous tin mines.

Intimate mixture with tinstone, either in the form of fine worn grains in alluvial drifts, or as finely comminuted particles in crushed lodestuff, necessarily depreciates the value of each mineral owing to the difficulty of separating, arising from practically equal specific gravities.

In tin smelting the presence of tungsten is objectionable in any proportion. Dr. G. Mackenzie, Manager of the Sydney Tin Smelting Works, informs me that the maximum quantity of tungsten ore which may be disregarded in tin smelting should not exceed 1 per cent.

The effect of tungsten in tin-smelting furnaces is to impede reduction and cause loss by scorification.

When possible separation of wolfram from tinstone is effected by cobbing and hand-picking; in finely comminuted material, however, fusion with common soda or sulphate is resorted to for the purpose of forming a soluble tungstate of soda which can afterwards be removed by washing.

Tungsten ores consist of compounds of tungstic acid with iron and manganese (wolfram, etc.), lime (scheelite), lime and copper (cupro-scheelite), and lead (stolzite). Of these wolfram and scheelite are the most common, and wolfram the most important commercially. In addition to the above are several alteration products of less importance.

The percentages of tungstic trioxide (tungstic acid), on which the market value depends, range up to about 77·5 in wolfram ores, and 80 in scheelite.

Tungsten ores have been recorded from the following localities within the Colony, many of which are known officially, others, however, are dependent upon the good faith of persons desiring assays made in the Departmental Laboratory.§

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* H. M. Howe, Metallurgy of Steel, p. 82.
† Trans., Am. Inst. Mg. Eng., xxii., p. 236-245.
‡ Trai et des Gites Mineraux et Metalliferes, ii., pp. 169 and 170.
§ For many of these localities I am indebted to the valuable register compiled by Mr. Trickett, of this Branch.

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REGISTER OF LOCALITIES.

Adelong.—Professor Liversidge gives the following description of scheelite from this locality :—* "A specimen from the Victoria Reef Gold Mine, Adelong, County Wynyard, was massive, but with a portion of a crystal showing on one side, of an amber colour, translucent, resinous lustre, brittle, splintery fracture. Hardness, 4·5 ; specific gravity, 6·097. Associated with a dark green chloritic veinstuff. The following analysis was kindly made for me by Dr. Helms :—

Loss at red-heat	·25
Tungstic acid	79·53
Lime	19·14
Alumina	·58
Magnesia	·07
	99·57

The above results correspond to the formula Ca. WO_4."

Armidale District.—From Gara Falls, about 12 miles from Armidale, a sample of scheelite was assayed in the Departmental Laboratory, in 1886, for a yield of 47·9 per cent. of tungstic acid. A sample in 1894, from the same district, yielded 66·29 per cent.

Berridale.—About 20 miles S.W. of Cooma.—Mr. Warden Love reported, in connection with the discovery of this locality, "A broken outcrop of quartz, containing wolfram, was traced for 100 yards, running east and west. An assay of a small sample yielded 69 per cent. of tungstic acid."† (D.M.A., 1891.)‡ Another assay was made in 1893, yielding 54·35 per cent. (D.M.A., 1893.)

Bingera.—Wolfram forwarded as coming from this locality yielded 72·46 per cent. tungstic acid. (D.M.A., 1893.)

Bundarra, 25 miles S.W. of Tingha, New England.—A sample received from this locality consisted of wolfram associated with arseniate and arsenide of iron in quartz, which yielded 44·94 per cent. of tungstic acid. (D.M.A., 1891.)

Burrowa District.—Both scheelite and wolfram occur in the neighbourhood of Frogmore, associated with both quartz and granite. Assays have yielded from 31·65 to 66·96 per cent. of tungstic acid. (D.M.A., 1891–2–3.) Prospecting failed, however, to discover any payable deposits.

Casino District, Richmond River.—From this district a sample of scheelite was assayed for a return of 75·30 per cent. of tungstic acid. (D.M.A., 1895.)

Clive County, Parish of Bengha.—Wolfram in a siliceous gangue, stained with arseniate of iron, forwarded from this locality yielded 42·55 per cent. of tungstic acid. (D.M.A., 1892.) It is also reported from Scrubby Rush, in the same County.

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* Minerals of New South Wales, 1888, p. 85.
† Ann. Rept. Dept. Mines and Agric. for 1891.
‡ NOTE.—Assays made in the Departmental Laboratory are marked D.M.A.), with the year.

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Cobar District.—Wolfram in quartz forwarded from this District yielded 53·70 per cent. of tungstic acid. (D.M.A., 1895.)

Cowra District.—Wolfram, yielding 67·80 per cent. tungstic acid, was forwarded for assay from this locality in 1893. (D.M.A., 1893.)

Cooma, 3 miles from.—Probably this locality should be Berridale. Wolfram reported as coming from near Cooma, yielded 54·95 per cent. tungstic acid. (D.M.A., 1891.)

Cordillera Hill, Tuena District.—Scheelite, cupro-scheelite and stolzite were discovered when opening the Cordillera Hill Silver and Copper Mine in 1888, but, so far, the above minerals have not been systematically searched for.

The Government Analyst, Mr. W. H. Hamlet, F.C.S., &c., for this Department made the following analysis of a massive sample of a dark greenish colour* :—

Tungstic trioxide	69·31	per cent.
Lime	19·35	,,
Silica	4·88	,,
Copper oxide	4·05	,,
Iron oxide	2·01	,,
	99·60	

Prior to this date, Mr. W. A. Dixon, F.I.C., F.C.S., detected the presence of stolzite (tungstate of lead) in this mine. Stolzite is also recorded from Broken Hill.†

Deepwater, New England.—Both wolfram and scheelite occur in the Bolivia district, the particular localities specified being Nine-mile, 10 miles east, and 20 miles from Deepwater, at Bald Rock; at the latter it occurs in quartz and felspar stained with arseniate of iron. At 10 miles east of Deepwater, ilmenite is associated with the wolfram in quartz. Assays from the above localities, made in the Departmental Laboratory in 1892–3–4, yielded from 47·02 to 73·10 per cent. of tungstic acid.

Ding Dong.—Between Deepwater and the Great Divide.—The late Government Geologist, Mr. C. S. Wilkinson, recorded the occurrence of wolfram at Ding Dong, where it is associated with tinstone in griesen.‡

Emmaville, New England.—Mr. T. W. E. David, B.A., F.G.S., thus refers to the occurrence of tungsten ores in this district:—"An important vein of wolfram occurs on the Mole tableland, 13¼ miles north of Emmaville in a direct line, but 21 miles distant by road. The point, at which the reef was observed to be rich in wolfram, bears west 36° south from the south-west corner of portion 407, parish Rockvale, county Clive, a quarter of a mile distant, and lies just outside the boundary of this parish, in the north-east corner of parish Flagstone, county Gough. The vein is, in places, from 10 to 12 yards wide, though probably not metalliferous throughout its entire width. Owing to the reef being covered over with iron-stained sandy soil, it is impossible to ascertain, by mere inspection, the average width or length of its outcrop, though surface indications favour the supposition that the reef is a strong one. The strike is about N. 40° E. As far as I am aware, this reef has never been prospected, and it is situated partly on Crown lands.

* Ann. Rept. Dep. Mines for 1886, p. 41.
† Records Geol. Survey N. S. Wales, 1896, v, pt. 1, p. 8.
Ann. Rept. Dept. Mines for 1883, p. 151.

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"Wolfram also occurs at the Gulf main vein, Hall's Grampians, Lee's Gully, and the Planet Mine, near the head of the Nine-mile Creek, parish Wellington Vale, county Gough.

"Scheelite has been found in small quantities at McDonald's veins, on the Glen Creek. The mineral is honey-coloured and translucent."*

Though it is understood that no very large amount of prospecting has been done on the Mole Tableland lode, yet there is sufficient to reveal the fact that the wolfram is confined to comparatively small bunches in the reef, though at the same time larger than any other known deposits of clean ore. There is no record of any assays in the Department from this locality, but from physical appearance, the ore is of first quality.

An assay made, in 1892, of rubble wolfram in quartz and mispickel from the Emmaville district yielded 64·06 per cent. of tungstic acid.

Elsmore, near Inverell.—A sample of wolfram in quartz from this locality yielded 67·20 per cent. of tungstic acid. (D.M.A., 1895.)

Frogmore, Burrowa District.—See Burrowa.

Glen Innes.—Mr. C. S. Wilkinson recorded the occurrence of wolfram, associated with bismuth, molybdenite and arsenical pyrites, in Portion 25, about half a mile north-west of Kingsgate, in a large pipe vein, consisting of a very ferruginous mass of quartz.

About 12 miles north from Glen Innes at Hogue's Creek, about 1 mile from the Tenterfield Road, Mr. Wilkinson described a larger occurrence of wolfram associated with the minerals already mentioned as present in the Kingsgate ore. He described the mode of occurrence as follows:—

"They form irregular veins and masses of quartz traversing a fine-grained micaceous felsite rock, which is surrounded by altered sedimentary rocks. In one place this rock, for a length about 100 yards and a width of 15 yards, is traversed by a network of quartz veins. A small hole has been sunk here, and the stone taken from it contains bismuth ores, tin ore, molybdenite, arsenical pyrites, and wolfram.

In another place, about 100 yards from the last-named, a mass of hard crystalline quartz, in size at the surface about 40 feet by 20 feet, has been opened for a few feet in depth. It contained bismuth and tin ores, together with a large quantity of wolfram"†

Mr. Wilkinson did not consider that the lodestuff could be profitably worked for tin ore owing to the large proportion of wolfram.

Quite recently Mr. C. S. McGlew has been opening up this deposit of wolfram. A certain amount of clean wolfram is obtainable, but the bulk of the lodestuff, so far as operations have yet extended, is much below the minimum grade.

Gara Falls.—See Armidale.

Grampians (Hall's).—See Emmaville.

Gulf Mine.—See Emmaville.

Gundagai.—Wolfram in granite, forwarded from the Gundagai District, was assayed for a yield of 61·44 per cent. of tungstic acid. (D.M.A., 1892.)

Guyra.—Scheelite from this locality yielded 75·60 per cent. of tungstic acid.

* Geology of Vegetable Creek Tin-mining Field, 1887, pp. 161–2.
† Ann. Rept. Dept. Mines and Agric. for 1888, p. 154.

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Hillgrove, Armidale District.—Scheelite was noted at Hillgrove shortly after the gold discovery, because of its association with the gold and stibnite of the reefs. No appreciable quantity has, however, been exposed in the extensive workings and prospecting of the locality. Assays made of a number of samples during 1892, 1893, and 1894, yielded from 38·25 to 71·80 per cent. of tungstic acid. The gold and antimony reefs of Hillgrove occur principally in slate country close to the junction of granite, and to a lesser extent within the granite also.

Inverell.—Professor Liversidge gives the following description of a sample of wolfram from Inverell:—

"A specimen found in quartz veins with tinstone, Inverell, county Gough, of the usual bronzy black colour, sub-metallic lustre, opaque, lamellar structure, with only traces of crystal faces, had the following composition:—

Tungstic acid	77·640
Iron protoxide	18·760
Manganese	4·121
	100·521*

Another sample recorded in the Departmental Assay Register as coming from 15 miles south of Inverell, yielded 73·40 per cent. of tungstic acid.

Jingellic, Upper Murray River.—Mr. E. F. Pittman recorded the presence of wolfram in the Jingellic tin lodes, which consist of quartz veins in granite. In No. 4 lode, which had been opened for 8 chains, the associated minerals were much arsenical pyrites, some wolfram and tourmaline, and a good percentage of tin ore.†

The tin lodes at Jingellic were abandoned shortly after Mr. Pittman's inspection owing (according to local report) to the failure to realise on some 9 tons of ore extracted, which may probably have been due to the presence of wolfram beyond the minimum limit of Australian smelters.

Mila, 14 miles south of Bombala, Monaro.—Wolfram occurs very sparingly distributed in a quartz reef in Mr. Cochrane's property, near Mila.

Mole Tableland.—See Emmaville.

Mount Hope.—North-west of Euabalong, Lachlan River.—Wolfram was discovered near Mount Hope by a Mr. Eason about the time of the gold discovery at Mount Allen in this neighbourhood. Several assays have been made which yielded from 62·57 to 72·2 per cent. of tungstic acid (D.M.A., 1892), but nothing is yet known of its mode of occurrence or probable quantity.

Mount Sutton, New England.—An assay sample from this locality yielded 71·22 per cent. of tungstic acid.

Nangeribone Run, via Nymagee.—Wolfram was detected in a sample of quartz from this locality, sent to the Department for examination.

New England.—Under this very broad definition of locality several samples of wolfram have been assayed in the Departmental Laboratory for yields from 56·50 to 70·75 per cent. of tungstic acid.

Newstead.—Wolfram from this locality has been noted, but nothing definite is known either of the exact locality or mode of occurrence.

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* Minerals of New South Wales, 1888, p. 85.
† Ann. Rept. Dept. Mines for 1881, p. 143.

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Pulletop Station, County Mitchell, Wagga Wagga District.—Wolfram occurs in the vicinity of Pulletop Creek in the Parishes of **Westby** and Barrandana, associated with tinstone in quartz veins close to the junction of slate and granite, and in drift originating fron denudation of the reefs. At the time of my inspection of this locality in 1894, about twenty loads of drift were run through a box-sluice for a yield of 5 or 6 cwt. of mixed wolfram and tinstone, an average assay of which yielded :—

	per cent.
Metallic tin	27·72
Tungstic acid	28·82*

A mixture of this character is unsaleable in the Colony, and owing to the practically equal specific gravities, the two minerals cannot be separated by mechanical appliances, though a large proportion of the wolfram could be removed by sieving, owing to the fact that all the larger fragments consist of that mineral, the tinstone being comparatively fine.

After considerable inquiry abroad, Messrs. Harrold Brothers, of 19, Bridge-street, Sydney, who were devoting considerable attention to the subject, ascertained that the mixture represented by the above assay had a prospective value in England of about £15 per ton, less about £3 cost of treatment.

Assays of other samples from Pulletop, made in 1894, yielded from 45·90 to 62·20 per cent. tungstic acid.

Purnamoota, Barrier Range.—A sample from this locality, received during the current year, was tested in the Departmental Laboratory for a return of 62·10 per cent. of tungstic acid.

Peelwood.—Scheelite has been reported from this locality. It is, however, more than probable that the occurrence recorded under this heading is identical with that of Cordillera Hill.

Severn River, near Emmaville.—Wolfram is recorded from this locality in 1886, which yielded, on assay, 74·41 per cent. of tungstic acid.

Tenterfield District.—Granular wolfram in clayey matrix, from this district, was assayed in 1893 for a return of 57·25 per cent. tungstic acid; and another sample, more specifically defined as coming from within 7 miles of Tenterfield, yielded 40·21 per cent.

The Gulf, New England.—See Emmaville.

Waukeroo, Barrier Range.—Wolfram is recorded from this locality, but no assays have been registered.

Wellington Vale.—Vegetable Creek or Emmaville district, which see.

Yeoval.—South-west of Wellington.—Cupro-scheelite was identified by Mr. G. W. Card, A.R.S.M., Curator, amongst specimens collected from Yeoval by Mr. E. C. Whittell, Field Assistant.†

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* Ann. Rept. Dept. Mines and Agric. for 1894, p. 113.
† Ann. Rept. Dept. Mines and Agric. for 1896, p. 143.

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NEW SOUTH WALES.

DEPARTMENT OF MINES AND AGRICULTURE.

New South Wales GEOLOGICAL SURVEY.

E. F. PITTMAN, A.R.S.M., Government Geologist.

MINERAL RESOURCES.

No. 3.

NOTES ON GOLD DREDGING

WITH REFERENCE TO THE

INTRODUCTION OF THE INDUSTRY INTO NEW SOUTH WALES.

BY

J. B. JAQUET, A.R.S.M., F.G.S.,

GEOLOGICAL SURVEYOR.

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Geological Survey, New South Wales,
Department of Mines and Agriculture,
Sydney, 22nd March, 1898.

Sir,

I have the honor to submit for publication Report No. 3 of the Mineral Resources Series, entitled "Notes on Gold Dredging in New Zealand," by Mr. J. B. Jaquet, A.R.S.M., F.G.S., Geological Surveyor.

It has long been known that the gravel in the beds of many of our rivers in New South Wales contain considerable quantities of gold derived from the redistribution of older (Tertiary) leads, and also from the denudation of auriferous reefs which occur in the country bordering the river channels. The difficulties of mining in the presence of large bodies of water has hitherto prevented the economical extraction of the gold from the river beds of this Colony, but the success which has attended river-dredging in New Zealand has now raised the question whether similar results cannot be obtained here.

Advantage was taken of Mr. Jaquet's recent visit to New Zealand to obtain from him a report upon the results obtained, as well as the machinery in use there, and it is hoped that this report will be of use in assisting the introduction of the river-dredging industry into New South Wales. It is, therefore, recommended that it be published in pamphlet form for distribution.

I have the honor to be, Sir,

Your obedient Servant,

EDWARD F. PITTMAN,
Government Geologist.

The Under Secretary for
Mines and Agriculture.

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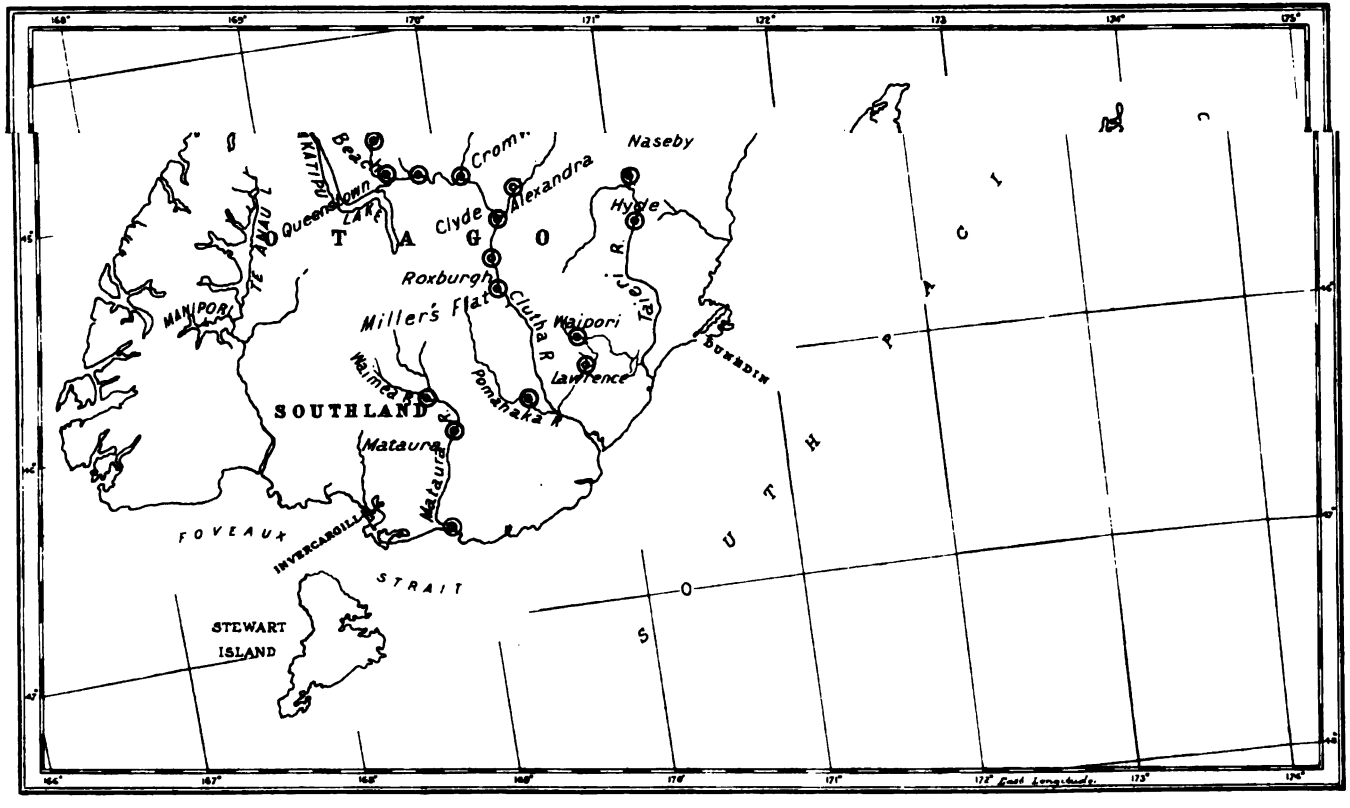

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NOTES ON GOLD DREDGING

WITH REFERENCE TO THE

INTRODUCTION OF THE INDUSTRY INTO NEW SOUTH WALES.

MINERS accustomed to exploit the gold-bearing gravels upon river-banks, and tantalised so often by being obliged to cease following some rich "run" of ground on account of it having dipped underneath the stream, have always desired a method which would enable them to baffle the water and prosecute their industry upon the river-bed. They may frequently be seen to look with longing towards the rich treasure which they believe to lie concealed there.

A consideration of the general geology of river-basins would seem to encourage them in this view, and tends to show that the submerged gravels should certainly be as rich, if not richer, than any found elsewhere in the valley. In many valleys we have evidence of the number of times the river has changed its course in the deposits of gravel and other detritus which are situated at various distances from the flowing water. The extent of these deposits, the altitude at which they occur, and calculations as to the rate of erosion, enable us to relatively measure, or at any rate form some rough idea of, the age of the river; and upon these data geologists have come to the conclusion that many streams have been flowing over constantly changing courses for immense intervals of time. The process of building up a gravel bed is no sooner completed than that of decay commences. The disintegration may take place rapidly, as when the erratic river returns once more to one of its old courses, or it may take place so slowly as to be scarcely noticeable within a man's lifetime. However, it is always going on, and after a certain interval has elapsed—it may be many thousand years—the constituents of every bed will be once more travelling down the river to a new resting-place, and finally a new cycle of changes will commence.

Now, I think it will be apparent that I have been describing a natural process of sluicing. The miner will recognise that the crumbling beds of stranded detritus represent the ground in the face of his claim, and that the river may be looked upon as a great sluice-box. He will understand why, as a general rule in the case of auriferous drifts, the younger beds in the valley are richer than the older ones, and why we should look for the richest ground in the river itself where the youngest deposits of all are to be found.

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Before the practice of dredging was introduced, it was only possible to win the gold from those portions of the river-bed from which the water could be diverted. Sometimes the stream was confined within smaller limits by means of a wing-dam; or a spot would be selected where the river flowing back on itself formed a "horse-shoe bend," so that the whole of the water could be diverted from a portion of the bed by means of a tunnel driven through the narrow neck of land.

The industry originated and has been brought to its present state of perfection upon the Clutha River, in the province of Otago, New Zealand. It has made considerable progress within the last few years, and has done much towards creating an era of increased prosperity in the province. Many mining townships which were ailing a short time ago, on account of gold-getting from ordinary sources having decreased, have had new life infused into them, and have once more become important centres of activity. A large amount of employment at good wages has been found, both for dredge-hands and mechanics, the latter being engaged in manufacturing and repairing dredges in the Dunedin workshops. About fifty dredges are now at work upon the Clutha and its tributaries.

I intended to have given particulars of the gold yields obtained by the various companies who publish returns. I find, however, that many of the most successful machines are privately owned, and no returns are available, so to do this would be to convey a wrong impression altogether as to the magnitude of the industry. A few remarkable yields recently obtained, and selected at random from those which came under my notice, will show how quickly the capital sunk in the industry has been in some instances recovered. The Electric No. 2 dredge, working near Cromwell, which cost £5,000 to build and launch, obtained more than this amount of gold within seven weeks after she started to work. A small "current-wheel" machine, working about a mile below Alexandra, obtained gold to the value of £3,570 during two months of last winter. The "Moa," belonging to the Clyde Dredging Company, Limited, a company which has only a capital of £4,000, for nine months' work, ending in September last year, obtained gold to the value of £10,156.

The quantity of gold which escapes the well-equipped modern dredge is small, and it is not possible under ordinary circumstances to profitably rework ground, so we may expect the rich bed of the Clutha to be worked out in a few years' time. However, the dredging industry will not cease with the exhaustion of this treasure. To such a state of perfection has it been brought that ground containing only a grain or a grain and a half of gold per cubic yard can now be worked at a profit; and, moreover, under certain conditions a dredge is able to cut a channel for itself through the river-bank and wander at the will of the engineer in charge over the bordering flats; or it may be launched to work low-lying auriferous flats, far removed from any river at all. Under the new conditions the yields of gold are not likely to be so sensational, but they will probably be more regular than they have been in the past.

A sketch map of the Middle Island of New Zealand will be found facing the first page of this paper, upon which the localities where dredging operations have been carried out are indicated.

The Clutha River.

The Clutha, also called Molyneux, carries down to the sea an enormous volume of water. "In 1864 the Provisional Government had the volume of the river carefully measured at a time when its waters were low, and the

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result was found to be something extraordinary, being not less than 1,690,400 cubic feet per minute. The following comparison with other large rivers was published at the time:—

	Cubic ft. per min.
Molyneux	1,690,400
Tay	274,000
Boyne	180,000
Thames	102,000
Clyde	48,000
Rhine	3,960,000
Rhone	649,000
Tiber	618,000
Saone	460,000
Arno	266,000
Nile	1,386,000
Irrawaddy	4,500,000

Thus the Clutha River, when at its lowest, was found to be larger than the Nile, six times the size of the Tay, nine times that of the Boyne, and sixteen times that of the Thames."* More recently, the late inspecting engineer, Mr. H. A. Gordon, has estimated the discharge of the Clutha as follows:—

	Cubic ft. per min.
Minimum	837,000
Maximum	5,040,000
Average	1,674,000

Being chiefly dependent upon the snows of the Southern Alps for its supply of water, the flow is consequently greatest during the summer months, and reaches a minimum in winter.

The Clutha itself heads from Lakes Wanaka and Hawea, and its chief tributary, the Kawaru, from Lake Wakatipu. These three lakes play an important part in the economy of the river. They cover in the aggregate an area of 237 square miles, and, by acting as reservoirs, regulate the flow and prevent floods occurring. The fall of the river from its source in Lake Wanaka to the sea averages about 10 feet per mile, and the current is for the most part very rapid.

The country upon the banks varies greatly in character. Here the water tumbles impetuously through a rocky gorge, where the mountains rise abruptly on either side, and elsewhere, it will flow, still travelling hurriedly, through extensive low-lying flats. The dominant rocks are contorted and much altered slates and schists, of Palæozoic age, which are overlain in places by horizontally bedded clays and sandstones. Interstratified with the latter rocks are beds of lignite. Central Otago is absolutely devoid of timber, and, by providing a cheap fuel for steaming purposes, these lignite beds have greatly assisted the dredging industry.

There are many auriferous rivers in Australasia, yet for a number of years has the practice of dredging been practically confined to the Clutha and its tributaries, and the question will arise: In what way does this New Zealand river differ from the others, and how is it better adapted for this method of gold-winning? As regards its swift current and large volume of water, the Clutha is certainly far ahead of other rivers in these colonies; it is also probably unique as regards the extent, richness, and general arrangement of its submerged gravels. There is, however, much to show that the first-mentioned characteristics have, on the whole, tended to retard rather than

* Handbook of New Zealand Mines, Wellington, 1887, p. 38.

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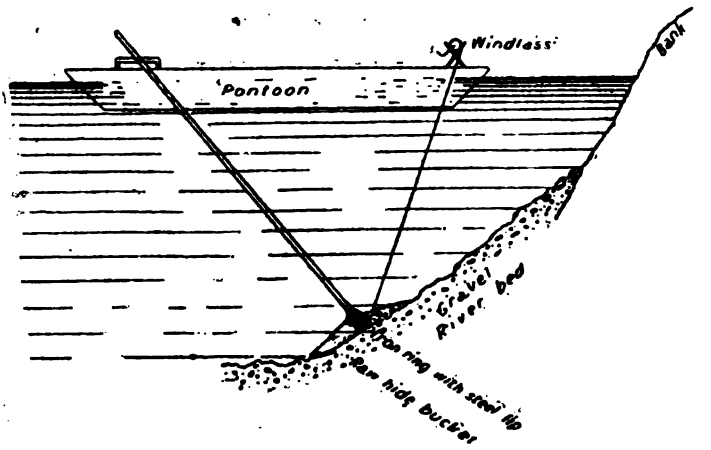
assist the industry. The best results have been obtained during the winter months, when the volume of water is at a minimum; indeed, many dredges are obliged to suspend operations altogether in summer. It is true, as I shall point out elsewhere, that, at one period in the history of the industry, the swiftly flowing water may have rendered good service by supplying power. Again, it may be of assistance in taking away the tailings. Yet it should be remembered on the other hand that a flow strong enough to carry off the tailings astern will also bring down silt from above, and deposit it in the "paddock" where the buckets are at work. When I was inspecting the Shotover River, a warm night, by accelerating the rate of melting of the snows upon the mountains, produced a slight fresh, and one of the dredges had to cease work for twelve hours, owing to the silt being deposited at a greater rate than it could be elevated. The best use is made of the current when the dredge can be moored, so that the buckets excavate into the bank or under still water, and only the elevator or tailings-shoot projects over into the running stream. The modern dredge certainly works to greater advantage in still shallow water, always provided that there is sufficient water to float the machine and wash the elevated gravel.

On the whole, I think the leading position occupied by the Clutha must be ascribed to its great wealth in alluvial deposits, and to the fact of the industry having been cradled and perfected upon its waters.

The Evolution of the Modern Dredge.

Spoon Dredges.—These primitive machines have been employed upon the Clutha ever since 1864. Their remains are to be seen in many places upon the river banks. They have also been occasionally used upon the Macquarie, and other rivers in our Colony. The sketch below is the outcome of descriptions given to me by miners and others.



The contrivance consisted of a long spar, terminating in an iron hoop, which supported a cow-hide bucket, capable of holding about a third of a ton of gravel. The spar swung upon a pivot placed near the stern of the pontoon, and was raised and lowered by means of a windlass erected in the bow. The dirt was emptied out of the bucket on to the deck, and was afterwards washed in an ordinary miners' cradle.

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A spoon dredge, even under the most favourable conditions, could only treat 2 or 3 tons of gravel per hour, as against the 100 tons which the modern steam dredge is capable of dealing with in the same period. Nevertheless, in the early days of gold-mining upon the Clutha, when the virgin ground in the river was not buried beneath vast deposits of tailings, as is the case to-day, good results were obtained, and not a few small fortunes built up as the result of the operation of these machines.

Current-wheel Dredges.—The next dredges placed upon the river lifted the gravel with a chain of buckets, and being provided with undershot wheels, derived their power from the river current (*see Plate VII*). The buckets discharged into sluice-boxes, which were supplied with water by a centrifugal pump. One or two of these machines are still upon the river, and from time to time do good work. The advantages which they possess as compared with steam dredges are as follows:—(*a*) Small first cost; (*b*) no fuel is consumed; (*c*) fewer hands are required. They labour, however, under one great disadvantage—being dependent upon the current for power, they are always obliged to keep well out in the stream, where during a considerable portion of the year the water may be too deep, or the deposit of silt too great, to permit of work being continued.

Steam Dredges were first launched upon the Clutha in 1881. They only differed essentially from the machines then upon the river in being provided with boiler and engines. They are able, when the river is high, to work along the bank or, by running up into the eddies and backwaters, in places where a minimum amount of silt is being deposited. Hence, with the introduction of steam, stoppages have been of shorter duration, and work has proceeded more regularly.

The introduction of a tailing-elevator.—When a dredge is working in still water there is always a tendency for the tailings to find their way back again into the excavation being made by the buckets. In designing the first machines endeavour was made to overcome this evil by raising the top tumbler, and causing the dirt to be discharged at as high an elevation as possible, so that sufficient fall might be obtained to permit of a long shoot being carried over the stern, by means of which the tailings could be discharged at some distance behind the pontoon. The limit to which it is possible to elevate in this manner is soon reached; and, moreover, the adaptation of this method tended to impair the general efficiency of the whole machine.

The difficulty was eventually overcome by lifting and stacking the tailings from the stern of the dredge by means of a bucket-elevator. The improvement was first applied by Messrs. Cutten Brothers, of Dunedin, to the "Enterprise" dredge (Plate VI), which was employed in working a beach upon the Clutha, near Alexandra. It may be said to have effected a revolution in the industry. The old machines were obliged to confine their operations to the rivers; the new ones, armed with an elevator, have been successfully employed in exploiting low-lying auriferous flats.

Sand pumps.—Attempts have been made to exploit the gravels of the Clutha River by means of suction pumps, but in every instance have failed. Similar results would seem to have been obtained in Montana, United States of America, where these machines were tested prior to the introduction of bucket-dredges.

The machines consisted essentially of a pontoon supplied with a powerful pump, which delivered its contents into sluice-boxes. As an instance of the costliness of the process, I may mention that a suction dredge working upon

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the Waiparapa Beach, near the mouth of the Mataaura River, was found to require 60 I.H.P. to lift on an average 15 tons of gravel per hour whereas a bucket-dredge of 30 I.H.P. would lift many times this amount in the same time.

General Description of a large Dredge.

The tendency at the present time seems to be to build larger machines. The initial cost under these circumstances is greater, and more fuel is consumed; but on the other hand, the cost for labour is the same as on a smaller dredge, and an increase quantity of gravel is treated.

The Electric Company's No. 3 *Dredge.*—This machine was being built at the period of my visit. When completed, it will be the largest dredge employed in gold-winning in New Zealand. It is expected that it will be launched in about five months' time to work ground upon the Kawarua River, about 3 miles above Cromwell. The pontoons are 120 ft. by 10 ft. by 7 ft., and are built in one piece. The well hole is 88 ft. long by 5 ft. wide. The deck beams project 2 ft. 6 in. on either side, so that the deck will be 30 ft. wide. The planking is kauri; the frames Tasmanian hardwood; and the stringers ironbark. The ladder will be 75 ft. long. The bucket belt will be made up of forty buckets and four sets of powerful grab hooks. Each bucket will weigh 10 cwt., and, having a full capacity of 6 cubic ft., will hold 5 cubic ft. when inclined at an average dredging angle. The total weight of the ladder and buckets will be 40 tons. A steam winch will be provided with six barrels. The revolving screen will be 22 ft. long and 4 ft. 5 in. in diameter. The tables for catching the gold will be 18 ft. wide and 17 ft. long. They will have a fall of 1½ inches in the foot. The screen will be supplied with water by a 10-inch centrifugal pump. The elevator will be 35 ft. between centres. Power will be obtained from a 16 H.P. horizontal compound Marshall engine, which will derive its steam from a half Lancashire and half tubular boiler, with a fire-grate area of 20 sq. ft. The total weight of the pontoons, with all the machinery, will be 200 tons. The expense of building and launching such a dredge will be about £6,000. Theoretically it will be able to elevate and wash 133 cub. yds. of gravel per hour.

The majority of the dredges upon the Clutha are very much smaller than the one described above. The buckets upon the Molyneux Hydraulic Company dredge have only a full capacity of 4½ cubic ft., and those upon the "Moa" only hold 3 cubic ft., while other dimensions are about in proportion. The length of ladder depends upon the depth of ground which is to be worked. It is not advisable to have the ladder too long, since under these circumstances the buckets are always inclined at a low angle, and their working capacity is, in consequence, lowered.

The frames and plating of some of the pontoons are made of steel, but experience seems to have shown that timber is better adapted for this purpose.

One plant—the Sandhills dredge—engaged in exploiting the upper Shotover, deserves some mention, in so far as it is the only one in New Zealand which is driven by electrical power. The pontoons are constructed of steel. They are 80 ft. long, and the deck has a width of 20 ft. The buckets have a full capacity of 3½ cub. ft., and discharge at the rate of twelve per minute. This I found to be the rate of discharge adopted upon all dredges. The dynamos derive their power from a Pelton wheel driven by a stream of water, which has been imprisoned upon the mountain side at a height of 524 ft. above the power-house. There are two motors upon the dredge, one of which drives the chain of buckets and the winches, while the other drives the centrifugal pump. At the

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time of my inspection the dredge was working at a distance of 3 miles from the dynamos generating the current. The cost of the dredge was £2,600, and of the whole installation £7,000. A full account of the plant will be found in the paper which has been contributed to the Institute of Civil Engineers, London, by Mr. Robert Hay, M. Inst. C.E.*

Gold-saving Appliances.

Upon the older dredges, and upon a few of the modern ones, the buckets discharge their contents by way of a shoot into ordinary sluice-boxes. The average length of boxes is 30 feet, and the fall about 1 in 12. The gold is caught either upon cocoa-nut matting or plush. Sometimes the boxes are provided with ordinary ripples, but more often they are fitted with punched iron plates, as shown in the section through a sluice-box given below. The

a. Iron plate, ¼-in. thick, with holes punched 1 in. apart.
b. Cocoa-nut matting.

large stones travel down upon the iron plates; the finer material and gold is washed by the water through the apertures, the latter being caught upon the matting. When the gold is very coarse tramway rails laid across the boxes have answered admirably as ripples. Mr. R. White has invented an arrangement of curved rail ripples, and applied the same to the Sandhills dredge under his charge. The curved rails ensure a more even lateral distribution of the material being sluiced.

With the introduction of the revolving screen a great advance was made in the process of treatment. The buckets discharge their contents into a shoot which leads into the upper end of the screen. Here a spray of water washes the fine material and gold through the perforations directly on to the tables arranged below, and the screenings are delivered by a shoot from the end of the screen into the buckets of the elevator, or, in the case of the older machines, directly into the river. The screens vary in length from 10 to 22 feet, and in diameter from 3 to 4 ft. 6 in. They make about ten revolutions per minute. The two screws upon the Molyneux Hydraulic Company's dredge have angle-iron worms inside, so that all the material passing into them, travels eight times the circumference of screen while under the influence of the water. In order to ensure a more even distribution of the fine sludge upon the tables, the perforations near the head of the screen are either of smaller size or are fewer in number than elsewhere. Water is supplied by means of a spray-pipe which enters the screen from behind. From 1,200 to 2,000 gallons of water per minute are required to ensure efficient washing.

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* Pro. Inst. of Civ. Eng., vol. cxxi, Par. iii.

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The tables for catching the gold are upon most dredges arranged in three shelves, so that the centre of each table is equidistant below the screen. They have in the aggregate a width equal to the length of the screen, a length of from 10 to 14 ft., and a fall of 1½ to 1¾ in. to the foot. They are covered either with cocoanut-matting or plush, which is overlain with ¼-in. mesh rectangular wire-netting. The latter is found to answer admirably as ripples. The percentage of gold which is lost in treatment upon the best-equipped dredges is probably very small.

That the tables equipped as above are capable of saving extremely fine gold has been shown by measurements which have been made of the particles. "A sample of fine gold from the Electric Company's dredges, about 2 grains in weight, which had been sifted through a sieve of about 3,600 holes to the inch was again sifted through one of 4,900 holes, and the gold which passed through sorted under a powerful lens. One hundred of the smallest of these pieces were thus selected, and examined under a microscope. Measured with a micrometer, their dimensions in fractions of an inch varied between 0·009 x 0·006 and 0·003 x 0·002, the mean of twenty measurements being 0·0065 x 0·0042. The hundred particles were then carefully weighed, and found to have a mass of 0·097 of grain. The mean weight of the pieces was therefore 0·00097, or a little under one-thousandth of a grain."* I have measured a number of particles of gold comprised in a parcel from the Electric Company's dredges, and obtained results almost identical with those given above.

The Dredge at Work.

To keep a large dredge running continuously a crew of six men are employed. The ordinary wage being £3 per week. The manager or dredge-master is usually a skilled engineer in receipt of from £4 to £6 per week. He does not as a rule work upon shift, but lives somewhere close handy to the machine, so that he can be quickly upon the spot in the event of any breakdown occurring. It often is arranged so that one manager has several dredges under his control.

A good system of partly paying the men by results has been introduced by the owners of the Turakina dredge, Messrs. Park. The men receive 8s. 4d. per shift, and a bonus of 10s. per week in the event of the weekly yield of gold exceeding 20 oz., and 15s. if it exceeds 30 oz. This method seems to me to be an admirable one. A dredge hand requires to use his head more than his hands, and there is scope in the work for the display of a considerable amount of judgment. The chief desideratum is to keep the machine running as continuously as possible and the buckets fully charged.

Two men are employed per shift. One attends to the winches, and the other does the stoking and looks after the engine. Before the introduction of the revolving screen the services of a third man were often required for the purpose of looking after the sluice-boxes. The winch-man is in charge of the shift; he keeps the dredge up to her work, and always keeps the up-coming buckets in view. Should a large boulder be lifted which is likely to damage the screen, he either breaks it when passing with a sledge hammer, or when it is not possible to do this stops the engine and levers it off.

* New Zealand Mining Journal, 1 Sept., 1897, p. 296.

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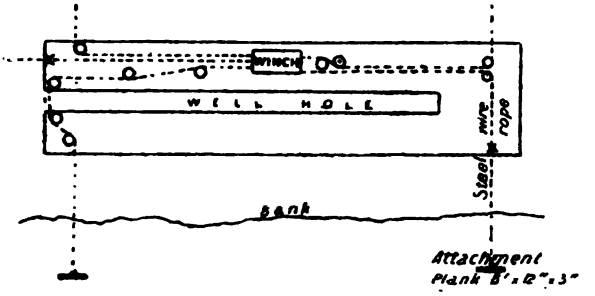
Boulders up to a ton in weight are sometimes raised upon the grab-hooks. When after several attempts it has been found impossible to raise one of these obstacles, endeavour is made by excavating a hole with the buckets alongside to cause it to roll from its position.

The dredge is kept in position by means of five steel-wire mooring lines, two starboard lines, two port lines, and one head line. The shore ends of the lines are passed around stout planks and buried in the soil. Each dredge is provided with an anchor, to be used in case of emergency.

Sketch illustrating Method of Mooring Dredge.



A dredge working into a flat cuts a passage for itself, breaking down the gravel in front and stacking it behind after it has been delivered of its associated gold. The greatest depth of ground (height of face) which it is possible to work is limited by the height of the elevator. In this connection it should be remembered that the elevated and loosely-packed gravel occupies a much greater bulk than when occurring *in situ*, consequently the depth of ground which it is possible for any dredge to work is always considerably below the height to which the same dredge is capable of elevating.

The Molyneux Hydraulic Company's dredge and other large machines can stack tailings up to a height of about 40 feet.

Dredge can be shifted over rapids or low falls.—This has been successfully accomplished upon the Shotover River by the manager of the Sandhills dredge, Mr. R. White, a system of locks being employed. The dredge is 95 feet long, and draws 2 ft. 6 in. of water. It is only when the river is in flood that there is sufficient water to float her; under ordinary conditions she has to cut a channel for herself. The greatest fall that has been negotiated is 15 feet in a length of 2 chains. Some of the rougher projecting rocks are first of all removed by a few charges of dynamite. The dredge is then hauled up as closely as possible to the rushing water, and a rude stone weir is built immediately behind it. This weir by impounding the water enables a forward movement to be made when a fresh wall is built, and the process is repeated until the top of the fall is reached. Four stone walls were required in the case of the highest fall, and the cost of the whole operation was trifling.

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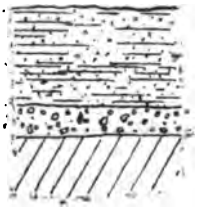
Problems for the Future.

Many low-lying auriferous flats are seen when examined in section to be made up as shown below.



Barren sand or sandy loam.

Gold-bearing gravel.

Bedrock.

Under these circumstances a difficulty will be experienced in keeping the dredge afloat, for the fine material, by passing through the apertures of the screen, will escape the elevator and be deposited around and underneath the pontoon. When the dredge attacks the flat from a swift-flowing river like the Clutha it may be possible by a judicious disposal of the tailings to divert a portion of the water so that there is always sufficient current astern to carry off the silt. However, the obstacle would be fatal to operations carried out in shallow still water in the absence of special precautions. An easy solution of the problem could be found in pumping the whole of the sluice-water with the fine material in suspension over the tailings heap; but this would necessitate a most extravagant expenditure of power. At least 1,600 gallons of water per minute are consumed in the washing-plant of an ordinary dredge; so, in the event of the tailings being stacked at an elevation of 20 feet, over 10 h.p. will be absorbed in lifting the water alone, where 16 h.p. is sufficient for all purpose upon the largest dredge. Engineers have for some time past been endeavouring to devise a method of overcoming the difficulty, and speak hopefully of being finally able to do so.

In one instance the pontoon was provided with a settling tank and small bucket elevator, which lifted the deposited silt and discharged it into the main elevator, so that it was carried up and stacked with the screenings. This arrangement does not seem to have answered very well. The elevator working in the sandy sludge was soon destroyed; and, moreover, no method of adjustment was provided, so the contrivance could not be used to work ground containing a constantly varying quantity of fine material.

Another obstacle which has caused dredge-owners to look askance at considerable stretches of river, which are otherwise well adapted for their purpose, is a hard, rough bottom.

A small quantity of very fine gold is scattered throughout the Clutha drifts; but the greater portion—at least 80 per cent.—is found in the crevices of the bedrock or in the layers of gravel immediately adjacent. Such being the case, it is evident that success depends in a great measure upon whether the upper layer of rock is soft enough to permit of its being scooped up by the buckets. Under other conditions not only is the gold not obtained from the crevices, but the motion of the buckets is impeded and likely to be suddenly checked by projecting rocks.

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The clayey sandstones which occur upon the river at Cromwell and elsewhere form an ideal bottom to work upon; but a difficulty is often experienced in those localities where the gravels rest upon the older slates and schists. It is necessary, however, that one should be very cautious in expressing an opinion as to whether a river-bottom is adapted for dredging or otherwise. Indeed, when the drift deposits extend to a great depth this question can only be satisfactorily answered after prospecting operations have been carried out. In several places upon the Clutha the same schists, which appear hard and unyielding upon the bank, have been found to be soft and pliable beneath the river.

In working upon flats or in shallow, sluggish rivers—and the majority of our New South Wales rivers are of this character—it may be possible to dredge close down to the bottom, and finally clean the same with the aid of divers. For the purpose of raising the small quantity of gravel which the buckets were unable to reach, and for cleaning out the crevices, sand-pumps controlled by the divers might, perhaps, be used with advantage. The rapid current would render it dangerous to employ divers upon the Clutha.

In this connection it is important to note that the gold in many river drifts is not confined to the bottom, but is more or less evenly distributed through a considerable thickness of gravel, or a portion of it may have been deposited upon a false bottom at some distance above the bedrock. While prospecting the auriferous gravels upon the Shoalhaven River, in 1893, I obtained, in many instances, a higher yield of gold from a false bottom than from the bedrock below; and several beds of gravel were tested in which no concentration of the precious metal upon the bottom could be detected. It is obvious that, under such circumstances, dredging might be profitably carried on, notwithstanding the presence of a hard rough bottom.

Another impediment to the industry is to be found in the occurrence of decaying logs or tree stumps. The Clutha is practically free from these obstacles; but they have given considerable trouble to the dredges working the Buller River, upon the west coast of New Zealand.

In the event of the auriferous ground being clayey there will be a tendency for it to adhere to the buckets. This might, perhaps, be provided for by causing a spray of water to play into them when they are discharging their contents. A much more serious difficulty will arise, however, in the event of the clay being present in sufficient quantity to render puddling necessary as a preliminary operation to the ordinary treatment. The process, besides absorbing a large quantity of water, is long and tedious; and, even should it be possible to successfully carry it out upon a dredge, its introduction would of necessity considerably lower the output.

Working Expenses of Dredge.

The weekly cost of running a large dredge in New Zealand is as follows:—

	£	s.	d.
Fuel—16 tons of lignite at 12s.	9	12	0
Labour—5 men at £3 and 1 at £5	20	0	0
Repairs, office expenses, &c.	20	0	0
	49	12	0

A large dredge working favourable ground is capable of elevating and washing at least 90 cubic yards of gravel per hour. For instance, the buckets upon the Molyneux Hydraulic Company's dredge have a capacity of 4½

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cubic feet, say 3½ cubic feet when inclined at an average dredging angle, and twelve bucket-loads are delivered per minute, so there should be 93 cubic yards delivered per hour. Suppose such a dredge to work twenty-two hours out of every twenty-four, and six days per week, then it will treat 12,276 cubic yards per week. Now, as the gravel in the buckets will be loosely packed and occupy a larger space than when in situ, an allowance must be made, and I propose to reduce the above amount by one quarter, this will leave it at 9,207. Suppose the gravel to contain gold at the rate of a grain (in round numbers a value of 2d.) per cubic yard, then the value of the precious metal won per week would be £76. Deduct 10 per cent. for loss in treatment (the loss under ordinary circumstances is nothing like as great as this), and the amount becomes £69. Again deduct the working expenses of the dredge £50, and £19 will remain. Hence it is possible by means of a large dredge to work ground containing only a grain of gold per yard at a profit. It must always be remembered, however, that the quantity of material which a dredge is capable of raising within a certain time varies considerably with the nature of the ground.

As an instance of the profits obtained in dredging low-grade ground, I will quote the published returns of the Jutland Flat (Waipori) Gold-mining Company for two years:—

	1896.	1897.
Dredging wages time for period	6,171	5,846 hours.
Actual lifting during same period	5,678	5,518 „
Estimated quantity lifted	402,919	398,608 cub. yds.
Gold obtained	1,135	1,177 oz.
Average yield of ground	1·35	1·41 grs. per yd.
Paid in dividends	£1,125	£1,875

During 1896, £707 was expended in litigation. If this amount is added to the dividends paid, the actual profit for this year, after deducting all working expenses, will stand at £1,832.

Gold Dredging in Montana, U.S.A.

I am indebted to an article contributed to the *Engineering and Mining Journal* by Mr. E. B. Braden, for all the information contained under this heading.*

Two varieties of machine are being employed—floating dredges, which have been constructed after the fashion of those working upon the Clutha River, and "Traction" dredges, which travel upon wheels, and are designed to work upon dry land. "River (floating) dredges are successfully operating on Grasshopper Creek in Beaver Head County; Traction or land mining machines are working satisfactorily at Washington Gulch, Deer Lodge County, and in Alder Gulch, near Virginia City."

The raising of auriferous gravel by means of suction pumps was tried first of all, and resulted, as was the case in New Zealand, in failure.

The first attempt to use a bucket dredge was made three years ago, but it was not until the dredge had been rebuilt twice that satisfactory results were obtained.

"The 'A. E. Graeter' was launched for the Bannock Dredging Company last June, and a plant for the Bon Accord Mines is almost completed. It is 102 feet in length, 32 feet wide, and draws 3 feet of water. With the

* Gold Dredging in Montana: Eugene B. Braden, *Engineering and Mining Journal*, Nov 20, 1897, p. 605

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engines, boilers, and other machinery carried, the total weight is nearly 700,000 lb. Steam is generated by two tubular steel boilers, of the locomotive type, with grates arranged to use pine and fir wood for fuel. There are thirty-five buckets, with a capacity of 5 cubic feet each, and excavations can be carried to a depth of 38 feet."

The dredge only seems to essentially differ from the larger New Zealand machines in regard to the arrangements for shifting and moving. "It is equipped at the rear end with two spud timbers 42 in. × 18 in. × 50 ft. in size, and weighing 11,000 lb. each. These are each fitted with a pointed steel wearing shoe at the lower end, and with the necessary gearing for raising and lowering. These spuds are for moving the dredge forward or backward, being alternately raised by means of hoisting cylinders of 24 tons capacity and dropped after the dredge has been swung by the engineer in the pilot-house through the cables passed around the front corners of the boat to a lateral anchorage. The boat is thus walked ahead. While excavating, one of these spuds rests in the gravel at the bottom, and forms a pivot, around which the boat is swung as the gravel is taken up. By means of the suspensory cables carrying the bucket-ladder, this ladder is lowered about 6 inches with each swing of the dredge around the anchored spud. Thus with the drag of the bucket a segment of gravel 6 inches deep and 8 feet wide is excavated. This lowering of the ladder continues until bedrock is reached. The bedrock, if yielding, is torn loose and brought up until barren of values."

The percentage of gold extracted is stated at 98 per cent. The cost of working gravel when steam is employed has been found to be 9 cents (4½ pence) per cubic yard. This includes labour, supplies, running repairs, and superintendence. On the "F. L. Graves," where electricity is employed for power, this cost has been 4½ cents (2¼ pence) per cubic yard.

"The traction dredge or land-mining machine at Washington Gulch has been designed to work in ground that is unusually flat, and where but little water is obtainable. It is owned and operated by W. M. Johnston & Co., of Chicago, who also designed the plant. The builders were the Marion Steam Shovel Company, and the Gates Ironworks. It works dry gravel, and where the machine cannot sufficiently clean the bedrock, this work is done by hand labour. The entire plant is supported on four bogie trucks which move on double tracks 12 ft. apart, laid on the bedrock. No jack-arms, side braces or spuds are used. Steam is supplied by one 50 h.-p. boiler to a set of dredging engines of the same capacity. These perform the excavations, handle the car, run the washer and trommel, and move the plant forward when required. The part of the machinery by which the excavating is accomplished is similar in design to that used for such purposes on steam shovels. The boom is 40 ft. long, and carries a dipper or shovel of 1¼ cubic yard capacity, and handles 70 cub. yds. per hour. The water supply to this plant for all purposes is 20 miner's inches.

In this gulch the bedrock lies some 16 ft. below the surface. Above this is the auriferous gravel on which is a considerable overburden of barren material. This latter is first stripped off and disposed of at the side without washing. The pay gravel is then taken up by the shovel and dumped into a car at the other side of the plant which runs on an incline. One end of this incline rests on a shoe set in solid ground on the bank of the cut, and the other terminates on the roof of the dredge. The car, when filled, is handed up by a cable, operated by the engines and pumped into a hopper on top of the plant. The gravel passes into a washer and trommel, when complete disintegration is effected, and the coarse gravel and rocks passed out at the

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rear end of the plant. The finer gravel, sand, gold, and water pass through the perforations of the trommel into a sluice box originating immediately below. This sluice extends some distance behind the plant, being carried by suspensory chains for regulating the grade. The saving of gold accomplished in this system is 97 per cent. and 98 per cent. The machine has operated ten hours every day since May 18th, with the exception of Sundays and one day while awaiting material with which to make repairs. Eight and sometimes nine men have been employed, three of whom do the work of cleaning the bedrock by hand. About 1½ cords of fir wood are consumed per shift of ten hours.

This dredge is the first of this design to be constructed. Others are being built which will embody improvements that have been suggested by the work done here."

Before concluding, I desire to convey my thanks to the Honourable H. J. Cadman, Minister for Mines, Mr. H. J. H. Elliott, Under Secretary for Mines, and numerous engineers and other residents of Otago, for the great kindness shown to me, and for the assistance they rendered me in obtaining the information set out in this paper.

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DESCRIPTION OF PLATES.

Plate I.

The Chicago Dredge.

A tailings elevator is here seen at work, and the variation between the height of the loosely stacked tailings and the face of ground being attacked is apparent.

Designed and built by Mr. K. S. Sparrow, engineer, Dunedin.

From photograph by W. Esquilant & Co., Dunedin.

Plate II.

The Moa Dredge.

It has been one of the most successful dredges upon the Clutha. The picture shows it working in the Clutha River a short distance below Alexandra.

Originally constructed according to the design of Mr. E. Roberts, and recently altered by Messrs. Cutter Brothers. From photograph by W. Esquilant & Co., Dunedin.

Plate III.

The Molyneux Hydraulic Co.'s Dredge.

This is probably the largest machine working at the present time upon the Clutha. The great length of the elevator (60 feet) enables the tailings to be stacked at any height not exceeding 35 feet. There are two revolving screens.

A nozzle has been erected upon the bow of the pontoon, so that when a steep bank is being attacked the ground can be "hydrauliced" in advance, and the risk of the ladder and buckets being buried beneath heavy falls thereby minimised. It is doubtful whether the advantages accruing from the use of the nozzle compensates for the large amount of power which it consumes.

At the time of my inspection the dredge was working into a face of gravel 25 feet high.

Designed by Mr. E. Roberts, consulting engineer, Dunedin. Reproduced from photograph by W. Esquilant & Co., Dunedin.

Plate IV.

The Earnsleugh No. 1 Dredge.

This dredge is represented leaving the Clutha River, and commencing to attack a river flat.

Designed by Mr. E. Roberts, consulting engineer, Dunedin. Reproduced from photograph by W. Esquilant & Co., Dunedin.

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PLATE V.

The Manorburn Dredge.

Here a dredge is seen exploiting an auriferous flat away from the river altogether. It is cutting a channel for itself, breaking down the bank of gravel in front, and stacking it, when delivered of its gold, behind.

The ladder, with the system of gear pulleys used for raising and lowering, are well shown.

Designed by Messrs. Cutten Bros., Consulting Engineers, Dunedin. Reproduced from photograph by W. Esquilant & Co., Dunedin.

PLATE VI.

The Enterprise.

An historic interest is attached to this dredge, in so far as it was the first one to be supplied with an elevator for the tailings. The elevator is shown at work.

Designed by Messrs. Cutten Bros., Consulting Engineers, Dunedin. Reproduced from a photograph by W. Esquilant & Co., Dunedin.

PLATE VII.

The Perseverance Dredge.

A "current wheeler" is here shown at work in the centre of the Clutha River, a short distance above Alexandria.

These machines being dependent upon the current for power can only work where the stream flows rapidly.

From photograph by W. Esquilant & Co., Dunedin.

PLATE VIII.

A portion of the Manukerikia River, with alluvial flats which are about to be exploited by dredges.

From photograph by W. Esquilant & Co.

PLATE IX.

A flat upon the Clutha, showing Hyde and party's No. 1 and No. 2 dredges and the "Perseverance" at work.

PLATE X.

Electric Company's No. 2 Dredge.

The galvanised iron house not having been erected, the general arrangement of the machinery upon the pontoon can be seen.

The machine is remarkable on account of its long ladder. It can dredge to depths of 60 feet.

Two pairs of grab-hooks, which enable boulders up to a ton weight to be raised, will be seen upon the bucket belt.

From photograph given to me by Messrs. McGeorge, of Cromwell.

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Plate XI.

Plan and sections of the A. E. Graeter dredge, which is working at Bannack, Montana, U.S.A. It differs from any of those upon the New Zealand rivers in being provided with two pivots, by means of which it can be anchored or moored short distances backwards or forwards.

The plate has been reproduced from that which accompanies the article on Gold-dredging in Montana, by Eugene B. Braden, "Engineering and Mining Journal," 20th November, 1897, p. 605.

Plate XII.

Plan and section of Matau Dredge, showin general arrangement of machinery.

This dredge has been designed by Messrs. Cutten Bros., Consulting Engineers, Dunedin. When completed it will be launched upon the Clutha River to work ground about 3 miles above Alexandria.

Reproduced from a photograph by W. Esquilant & Co., and supplied to me by Mr. W. H. Cutten.

Plate XIII.

The Kawarau dredge, designed by Mr. J. C. McGeorge, consulting engineer, Dunedin, to work very deep ground. It has the longest ladder of any machine in New Zealand. When launched, it was supplied with an elevator 25 feet long, and the revolving screen was lengthened 4 feet.

Drawings of an elevator, with chain of buckets detached, have been added. The plate has been prepared by Mr. O. Trickett, draughtsman to the survey, from the tracing which was supplied to me by Mr. A. McGeorge, engineer, Cromwell.

Reference to Plan and Section.

A. Gantry, with gear-pulleys for raising and lowering ladder.
B. Ladder.
C. Winches.
D. Anchor winch.
E. Engine.
F. Boiler:
G. Tumbler, driving bucket belt.
H. Revolving screen.
J. Screen pipe.
K. Screenings shoot.
L. Gold-saving tables.
M. Pump.
N. Starboard mooring lines.
O. Port mooring lines.
P. Head mooring line.

[Plates, &c.]

Sydney: William Applegate Gullick, Government Printer.—1898.

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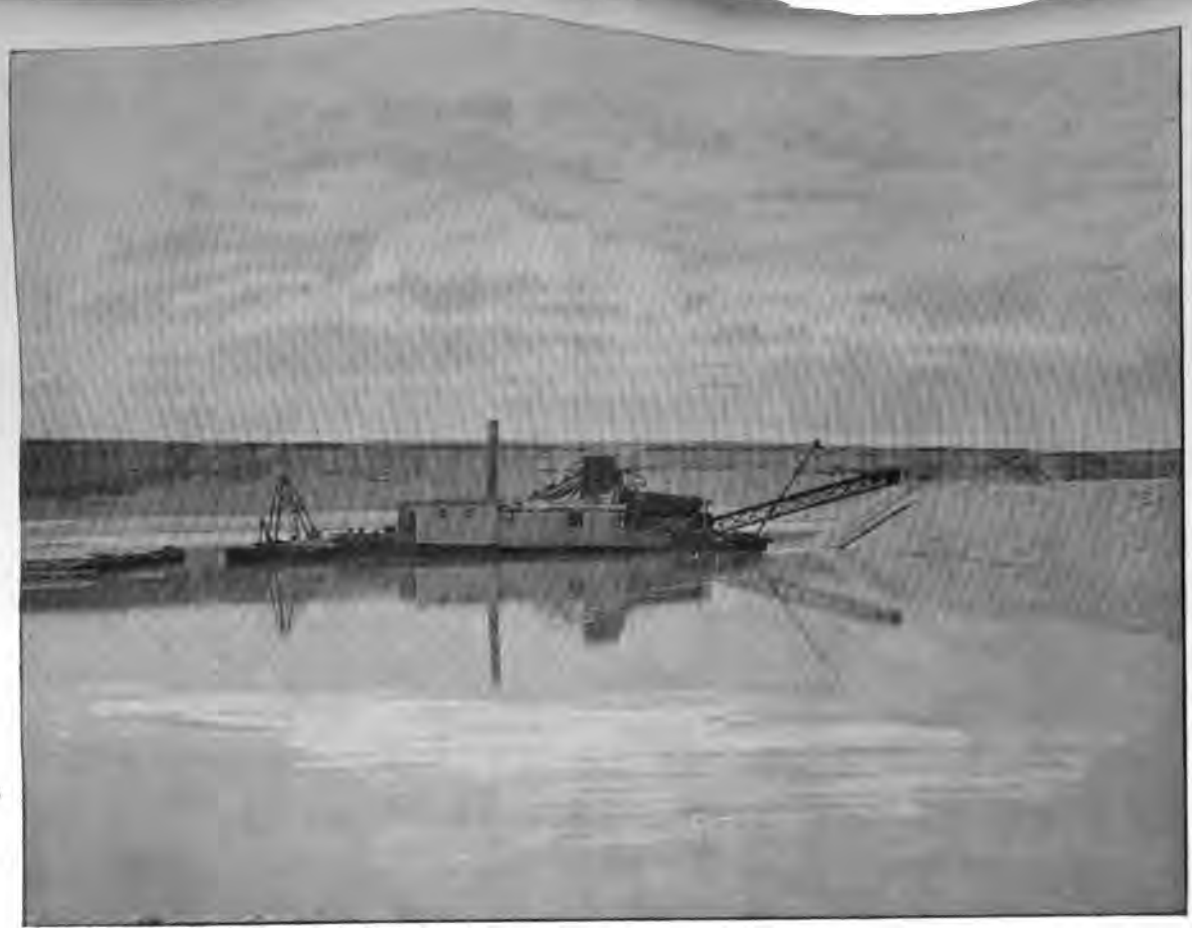

THE CHICAGO DREDGE.

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THE MOA DREDGE.

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PLATE III.

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THE EARNSCLEUGH No. 1 DREDGE.

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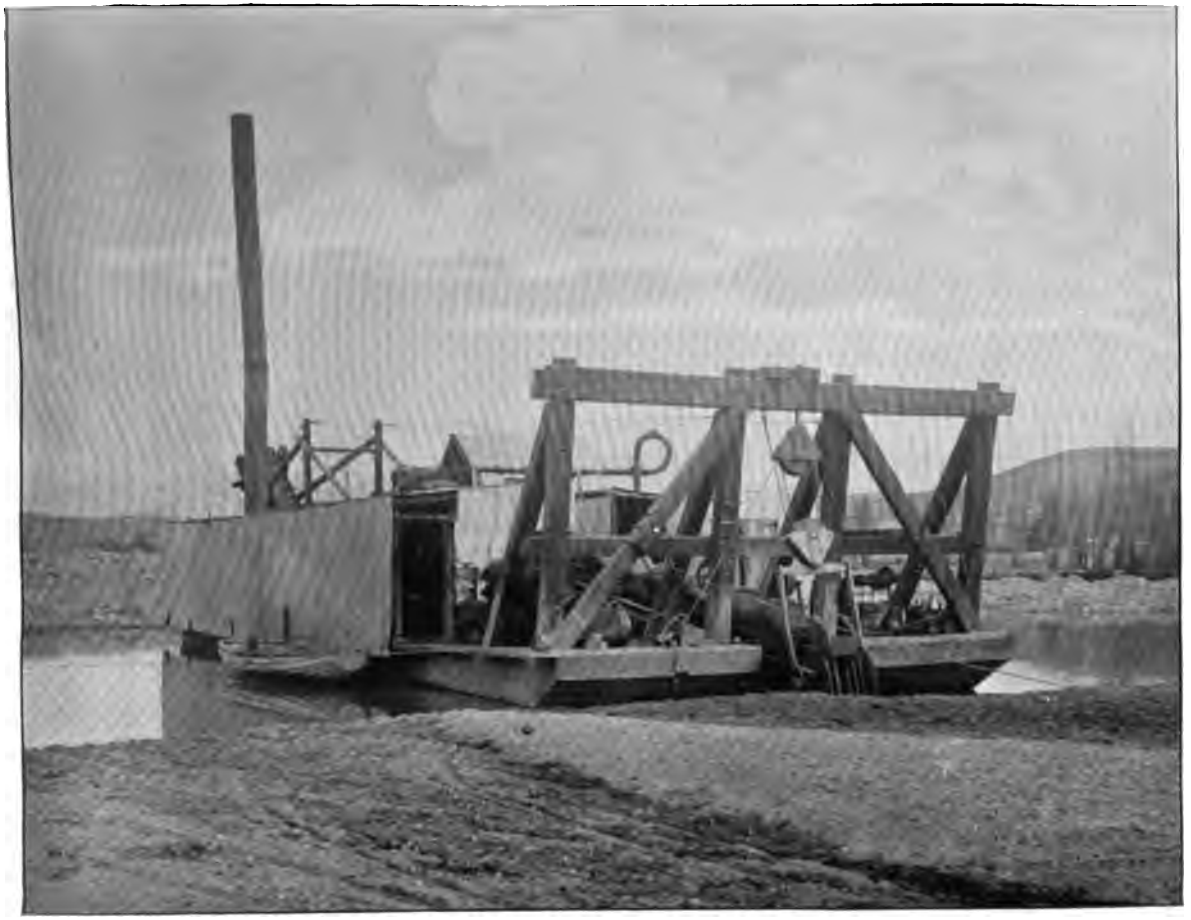

THE MANORBURN DREDGE.

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THE ENTERPRISE DREDGE.

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PLATE VII.

THE PERSEVERANCE DREDGE.

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MANUKERIKIA RIVER.

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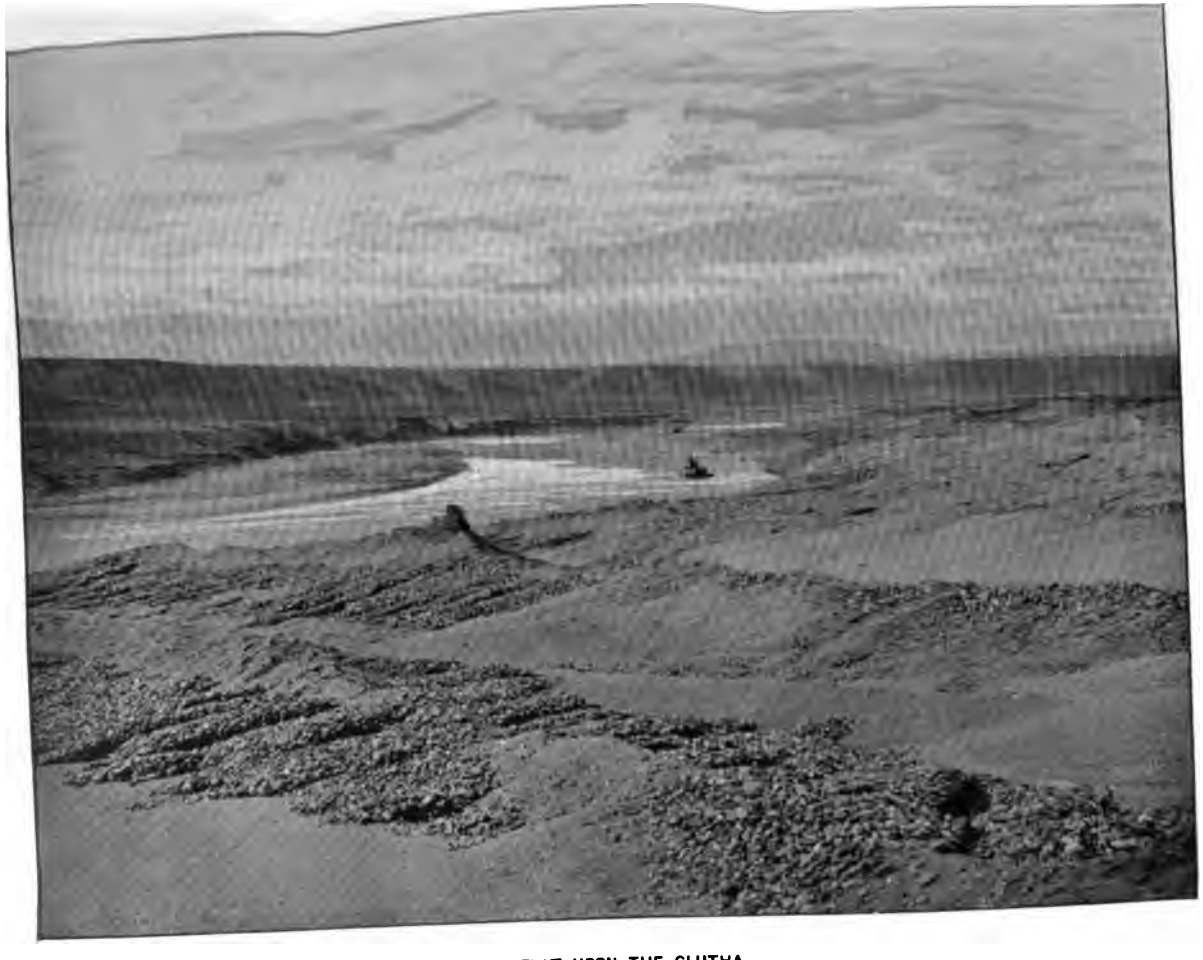

A FLAT UPON THF CLUTHA.

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PLATE X.

ELECTRIC CO.'S No 2 DREDGE.

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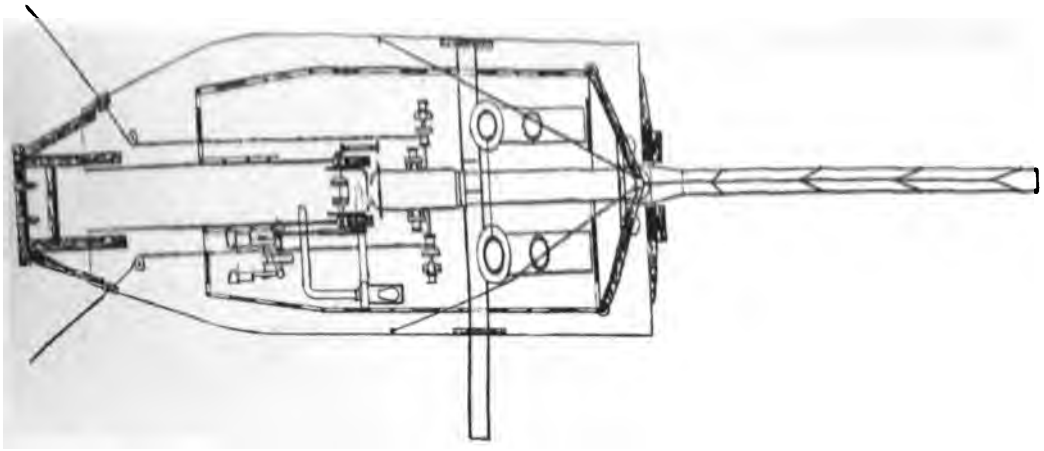
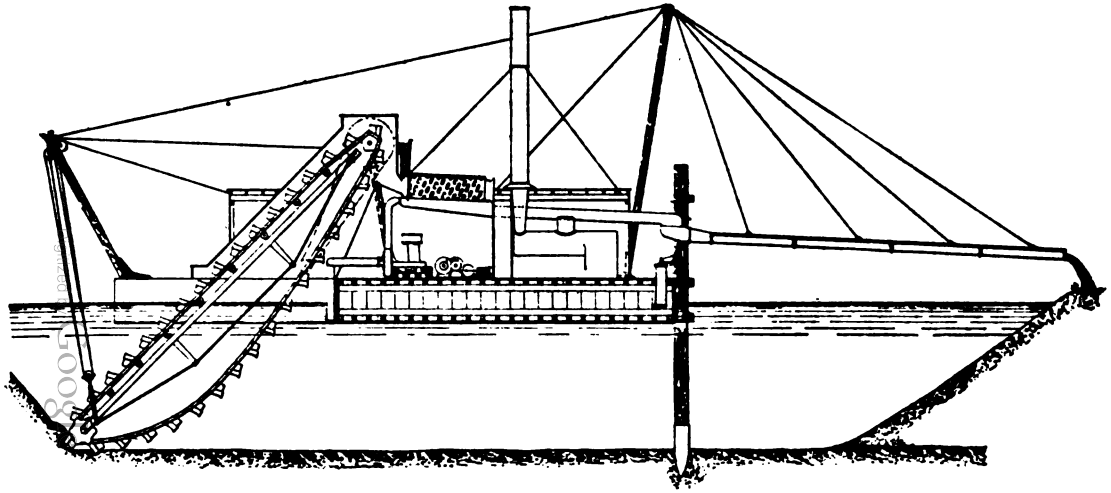
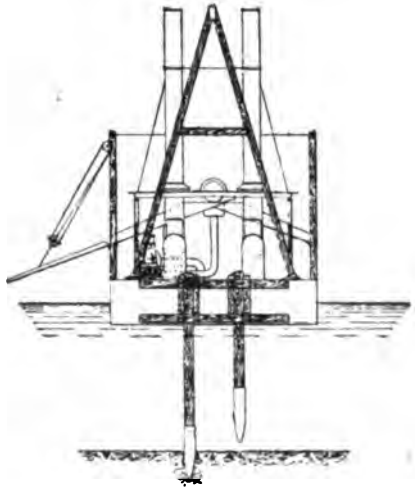
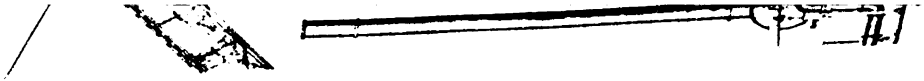
Plate XI.







Plan and Sections of "A.E.Graeter" Dredge.



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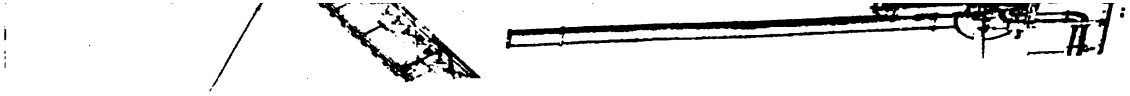

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NEW SOUTH WALES.

DEPARTMENT OF MINES AND AGRICULTURE.

GEOLOGICAL SURVEY.

E. F. PITTMAN, A.R.S.M., Government Geologist.

815.8.a

MINERAL RESOURCES.

No. 4.

NOTES

ON THE

OCCURRENCE OF BISMUTH ORES

IN

NEW SOUTH WALES.

BY

J. A. WATT, M.A., B.Sc.,

GEOLOGICAL SURVEYOR.

1898.

SYDNEY: WILLIAM APPLEGATE GULLICK, GOVERNMENT PRINTER.

1898.

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Geological Survey of New South Wales,
Department of Mines and Agriculture,
Sydney, 7th September, 1898.

Sir,

I have the honor to submit for publication Report No. 4 of the Mineral Resources Series, entitled "Notes on the Occurrence of Bismuth Ores in New South Wales," by Mr. J. A. Watt, M.A., B.Sc., Geological Surveyor.

There have been in the past numerous inquiries at the Department of Mines in regard to the production of the various metals and ores of New South Wales, the different localities in which they are found, their uses, and particulars as to their mode of occurrence. Much time was consumed in answering these inquiries, more especially as it was necessary, in most cases, to refer to a number of Annual Reports in order to collect the information required.

With a view of making information in regard to the mineral wealth of the Colony more easily accessible to the public, and at the same time bringing it up to date, the idea was conceived of issuing a series of short monographs under the general title of "Mineral Resources," each of which should treat of a separate metal or ore.

The success which has attended the publication of the three first monographs on "Chromic Iron Ore," "Tungsten Ores," and "Gold Dredging," respectively, is proof that the mining community recognise the advantages of being able to obtain complete information in regard to any metal in a concise and handy form.

It is hoped that the present number, on Bismuth Ores, will be found as useful as those which have preceded it.

Other monographs are in course of preparation, and will be issued as soon as possible.

I have the honor to be, Sir,
Your obedient Servant,
EDWARD F. PITTMAN,
Government Geologist.

The Under Secretary for
Mines and Agriculture.

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Notes on the Occurrence of Bismuth Ores in New South Wales.

CONTENTS.

I. Introduction.
II. Alphabetical List of the Localities in New South Wales from which Bismuth Ores have been recorded.

NOTE.—No claim is laid to originality as regards the contents of this paper. In writing the introductory portion liberal use has been made of text-books and scientific papers dealing with the subject; and in the remainder there is little more than may already be found in the Annual Reports of this Department. The information that was scattered through so many publications has been brought together, and thus made available for the use of those interested in this branch of the Mining Industry.

I.—INTRODUCTION.

Properties of Bismuth.—Bismuth is a comparatively rare metal of a silver-white colour, in which a distinctly reddish tinge is noticeable. This metal, which has a specific gravity of 9·83, melts at a temperature of 270° C. (507° F.).

On passing from the fused to the solid state, it increases considerably in volume; on this property, coupled with its low fusibility, many of the uses to which bismuth has been applied depend. Metallic bismuth is so brittle that it can be readily pulverised.

As to its chemical properties, we find that nitric acid, and a mixture of that with hydrochloric acid dissolve bismuth readily. From solutions so formed the bismuth is easily precipitated by the addition of a large quantity of water, or, better still, by pouring the solution into a large volume of water. From the nitric acid solution the bismuth is precipitated, by the method just described, as a basic nitrate, a white insoluble compound, which has been largely used as a cosmetic, and is somewhat extensively employed in medicine. From a solution obtained by the use of the mixed acids a white precipitate of the oxychloride is formed.

Chief Ores of Bismuth.—Bismuth occurs in nature principally as native or metallic bismuth; but with this are associated, especially in the upper portions of lodes where a process of oxidation has been going on, other compounds, such as the oxide and carbonate, which occasionally occur in sufficient quantities to be economically important.

The sulphide (Bismuthinite, Bi_2S_3) is also not an uncommon ore. It usually occurs massive, with a foliated or fibrous structure, and has a metallic lustre and lead-grey colour. The carbonate (Bismutite, $Bi_2O_3.CO_2.H_2O$) varies in colour from white to straw-yellow and yellowish green. The only other compound that it is necessary to mention here is the telluride (Tetradymite), a mineral of a steel-grey colour and metallic lustre.

The ores are almost without exception associated with other metallic minerals which are the primary object of the mining operations, the bismuth being treated as an accessory constituent of the ores.

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Tests for Bismuth in Ores.—The ordinary bismuth ores are not difficult to identify, owing to their low fusing points. If the presence of bismuth is suspected in any mineral, a small piece of it should be placed on charcoal and the blowpipe flame applied to it. Should the mineral fuse easily, and the charcoal in the vicinity of the fused mass become coated with an incrustation which is orange-yellow while hot, and lemon-yellow when cold; and, moreover, if a metallic globule remains on the charcoal, which is brittle and does not mark paper, it may be safely concluded that a bismuth mineral is present.

As a corroborative test, a portion of the mineral might be powdered and heated with nitric acid, and a small portion of the solution poured into a large volume of water, when a white precipitate, or with small quantities a turbidity, announces the presence of bismuth.

A good test is the heating of a little of the mineral, previously powdered, with sulphur and a little iodide of potassium, when, if bismuth be present, a beautiful bright-red incrustation will be formed on the charcoal.

Antimony ores, which resemble those of bismuth in their easy fusibility, may be readily distinguished from the latter in that they give a white incrustation when heated on charcoal, and are insoluble in nitric acid.

Uses.—The uses that have been made of bismuth and its compounds are few, and, consequently, there is but a limited demand for the metal.

One of the most important applications to which the metal has been applied, is in the production of fusible alloys, whose valuable properties depend on their low fusibility and the phenomenon of expansion during solidification. Bismuth alone fuses at a very low temperature, viz., about 270° C., but some of its alloys fuse at much lower temperatures, much below that of boiling water.

The most important of these alloys are:—

	Bismuth.	Lead.	Tin.	Cadmium.	Melting-point.
Newton's Metal.. ...	8 parts	5 parts	3 parts	.....	94·5° C.
Rose's ,, ...	5 ,,	3 ,,	2 ,,	.....	91·6° C.
Wood's ,, ...	15 ,,	8 ,,	4 ,,	3 parts	68° C.
Fusible ,, ...	2 ,,	1 ,,	1 ,,	.....	93·7° C.

Alloys consisting of lead, tin, and bismuth, mixed in such proportions that the mixture fuses at some particular temperature above 100° C., have been employed for safety plugs for boilers, but it is said that they have been found untrustworthy owing to the separation of the more fusible components of the alloy, when the plugs have been subjected to continuous heating near its actual melting-point. Alloys have also been used in automatic sprinklers placed in the ceilings of buildings as a safeguard against fires. The apertures of the sprinklers are closed by plugs of the alloy, which melt when unduly heated, and thus allow the water to flow from the sprinklers.

Fusible alloys have been used in stereotyping, in obtaining copies of woodcuts, &c.

The basic nitrate of bismuth is used in medicine, and as a cosmetic; and this compound, as well as the oxide, is employed in the manufacture of a highly refractive glass, and to give a colourless iridescent glaze to the surface of porcelain. Other compounds are also somewhat extensively used as medicines.

Occurrence of Bismuth Ores in Nature.—Although bismuth ores are known to occur in many countries, the deposits of economic value are comparatively few. The chief European mines which furnish bismuth ores are those of Schneeberg, Altenberg, Annaberg, and Johanngeorgenstadt, in Saxony, which were, indeed, at one time the sole producers of these ores. In these mines the bismuth occurs chiefly in the native state; but the sulphide and the

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carbonate are frequently present. At Schneeberg the bismuth ores occur in cobaltiferous veins. In the Austrian Erzgebirge, Bohemia, ores of bismuth are found in the argentiferous veins near Joachimsthal, and in tin-bearing deposits. At Rezhanya bismuth occurs as a telluride, associated with the tellurides of the precious metals. Austria, between the years 1869 and 1895, produced 9,638 metric tons of bismuth ore, nearly the whole of which went to the Saxon Works for treatment.

Prussia has produced small quantities of bismuth ore.

Important deposits of bismuth ore occur at Tasna and Chorolque, in Bolivia, which contain also tin and the noble metals. Bismuth occurs in these places in the native state, and as ochre and carbonate—the ores containing from 20 to 30 per cent. of bismuth.

The ores of Chorolque are found in porphyry, while those of Tasna are in slates. These mines are said to have enough ore in sight to supply the whole world for several years to come; but only sufficient is sent to the market to meet the small demand.

At Meymac, in France, bismuth ores were at one time obtained. They occurred there in a vein in granite, which contained wolfram and arsenical pyrites near the surface, and bismuth ores at greater depths.

Bismuth ores are known to occur in nearly all the Australian colonies; but they have been obtained in quantity only in Queensland and New South Wales. In Queensland, bismuth deposits exist at Mount Biggenden, Mount Shamrock, on the Percy River, and at Eukalunda. Between 1891 and 1895, inclusive, 452 tons of ore were exported from Queensland.

The great bulk of the bismuth of commerce comes from the Saxon Works at Schneeberg; a little also from Freiberg and Altenberg. Bismuth is also produced in England, where Australian and Bolivian ores are treated.

II.—Bismuth Ores in New South Wales.

Coming now to the more immediate object of this paper, an alphabetical list is now given of the localities in New South Wales from which bismuth ores have been recorded. Against the name of each place is given the information contained in the official records of the character of the ores, and their mode of occurrence at that place. The information here furnished is rather meagre. This arises from the fact that in the case of only two of the deposits have geological examinations been made; while the great bulk of our knowledge consists of the results of assays of samples sent to the Departmental Laboratory. This accounts for the absence of knowledge as to the exact localities from which many of the samples have been derived.

The late Mr. C. S. Wilkinson made an examination of the Kingsgate deposits in 1883, and in 1889 the Mount Mitchell deposits, near Glencoe, were reported on by Mr. W. Anderson.

The limited demand for the metal, and the manipulation of the market by a "Ring," are factors that have greatly retarded the development of our bismuth deposits.

Note.—The following abbreviations are made use of:—

D.L.—Departmental Laboratory attached to the Geological Branch.

A.R.—Annual Report of the Department of Mines and Agriculture; when the year is given, it means the Report for that year, which is published during the following year.

Bi.—Bismuth.

Au.—Gold.

Ag.—Silver.

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The results of assays are always given in percentage of metallic bismuth, and in ounces, pennyweights, and grains of gold and silver per ton.

Adelong.—Picked specimens of quartz containing iron pyrites, mispickel or arsenical pyrites, and metallic bismuth from a reef in the vicinity of Adelong were assayed in the D.L. in 1879, and found to contain Bi. 5·6 per cent. Mr. Slee, Chief Inspector of Mines, has mentioned the association of iron, copper, and arsenical pyrites, as well as zinc blende, and galena in the richest quartz of the Adelong Gold-field.

Bombala, 20 miles west of.—In A.R. 1894, p. 56, an assay is given of a sample stated to have come from a locality 20 miles west of Bombala. As there is no other record of bismuth ore from this locality, while similar ore occurs at Whipstick, which is about an equal distance east of Bombala, it is very probable the sample came from there. It yielded Bi. 14·83 per cent., Au. 11 dwts. 20 grs., Ag. 7 dwts. 14 grs.

Broken Hill.—See Mount Gipps.

Captain's Flat.—See Norongo.

Cobar.—Nine samples of copper ore from the Great Cobar Copper Mine, assayed in 1878, were all found to contain bismuth. The amount of this metal present in the ores varied from 0·21 per cent. to 2·58 per cent., the average of the nine samples being 1·53 per cent. The presence of this bismuth caused some difficulty in the refining operations. An analysis of the refined copper made in 1878 showed it to contain 0·419 per cent. Bi.

Deepwater.—See Pye's Creek.

Dundee.—A sample of quartz, wolfram, and carbonate of bismuth from this locality was assayed in 1897, and gave Bi. 1·42 per cent.

Emmaville.—Several small pieces of native bismuth encrusted with oxidized products were received at the Curator's office in May of this year. These were said to have been obtained at a place 3 miles from Carpet-snake Creek, in the Emmaville district.

Ewingar.—See Solferino.

Germanton.—Two samples from this place were assayed in 1890; one consisting of quartz with sulphide and carbonate of bismuth yielded Bi. 6·49 per cent., and the other, consisting of quartz with felspar, mica, oxides of tin and molybdenum, and molybdenite, yielded Bi. 0·99 per cent.

Glen Creek.—Two samples purporting to come from Glen Creek, near Emmaville, were assayed in 1897; one, containing carbonate and sulphide of bismuth, gave Bi. 2·77 per cent., the other, consisting of arsenical pyrites with clay, gave Bi. 0·96 per cent.

Water-worn fragments of bismuth have been recorded (See Prof. David's Memoir on the Vegetable Creek Tin Mining Field, page 163) from near Taylor's veins, on the Glen Creek.

Glen Innes.—One of the earliest references to the occurrence of bismuth ores in this Colony is that by Mr. Martin, Warden for the district, in A.R. 1877, page 109, where he says: "On this eastern watershed (of the New England Table-land) bismuth has been found in many widely separated places, and in one instance traced to the lode." The Kingsgate deposits are in all probability referred to here. See Kingsgate.

Glencoe.—See Mount Mitchell.

Gulf.—Mr. Slee, Chief Inspector of Mines, reported in 1880 having seen metallic bismuth near the Gulf, Vegetable Creek.

Gumble.—In 1886 a crushed sample of mineral, which was said to have come from Gumble, near Molong, gave on assay Bi. 11·76 per cent. A lode, from which the above sample probably came, was found on private land between Gumble and Delaney and Kelly's Mine. It was 2 feet in width,

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and a shaft 30 feet in depth was sunk on it. Samples from this lode were said to have yielded from 3 per cent. to 18 per cent. Bi., and 4 oz. silver per ton.

Highland Home, Parish of.—Lumps of native bismuth weighing a quarter of a pound, have been picked up near Burn's Reef, in Portion 3, Parish of Highland Home, County Gough. (See Prof. David's Memoir previously referred to.)

Hillgrove.—Three samples, said to have come from Hillgrove, were submitted for assay in 1891. Two consisted of quartz with a little carbonate of bismuth. One of them gave Bi. 12·11 per cent., Au. 4 dwts. 8 grs., and Ag. 3 oz. 18 dwts. 16 grs., and the other Bi. 3·37 per cent., Au. trace, and Ag. 1 oz. 12 dwts. 16 grs.

The third sample, which was a quartz-sand, which had been previously washed, contained a little carbonate of bismuth and cassiterite, and gave on assay Bi. 24·42 per cent., Au. 10 dwts. 21 grs., and Ag. 11 oz. 6 dwts. 11 grs.

Another sample from near Hillgrove, consisting of felspathic lode-stuff with galena, assayed in 1893, gave Bi. 4·74 per cent., Au. trace, and Ag. 6 oz. 17 dwts. 3 grs.

Hogue's Creek.—In his report* on the bismuth lodes near Glen Innes, Mr. Wilkinson mentions that "about 12 miles north from Glen Innes, and about 1 mile east from the Tenterfield road, several bismuth and tin-bearing quartz-veins have been discovered. These occur in a different manner from those at Kingsgate. They form irregular veins and masses of quartz traversing a fine-grained micaceous felsitic rock, which is surrounded by altered sedimentary rocks. In one place this rock, for a length of about 100 yards and a width of 15 yards, is traversed by a network of quartz-veins. A small hole has been sunk here, and the stone taken from it contains bismuth ores, tin ore (cassiterite), molybdenite, arsenical pyrites, and wolfram. In another place, about 100 yards from that last named, a mass of hard crystalline quartz, in size at the surface about 40 feet by 20 feet, has been opened for a few feet in depth. It contains bismuth and tin ores, together with a large quantity of wolfram.

"Besides this, two other small veins of quartz, yielding bismuth and tin ores, crop out close by. I do not consider that the vein-stuff here can be profitably worked for tin on account of the occurrence in it of so much wolfram; but for bismuth mining the prospects are encouraging, and the reefs should be further tested."

Kingsgate.—In this locality the most important of the known bismuth deposits of the Colony occur, and these have furnished the greater portion of the ore produced in the Colony.

Developmental work seems to have commenced at the mines on the Kingsgate Run in 1879, during which year a bulk sample of 8 cwt. of ore was raised and sent to Sydney. In A.R. 1880, page 143, Mr. Warden Martin gives the following particulars of the bismuth lodes at Kingsgate:—

"Although bismuth has been long known to exist in the district, mining for the ore is an industry only six months old, and was commenced at Kingsgate, 18 miles easterly of Glen Innes. Originally the land at this spot was taken up for tin, but indications showing that ores of bismuth were abundant, led to that metal being alone mined for. The lodes in which the ore is found are 6 to 8 feet wide, with an east to west bearing, and probably a north and south connection. There are many of them exposed on their bearing for

* Report on Auriferous Antimony Lodes at Hillgrove and Bismuth Lodes near Glen Innes. By C. S. Wilkinson. Ann. Rept. Dept. Mines N. S. Wales for 1888, pp. 154–155.

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a length of about 10 chains. The matrix is quartz. The country is rough and wild and of granitic formation, backed by basalt-covered table-lands about 3 miles distant from the mine.

"The Manager of the Kingsgate Mining Co., in his report for the half-year ending 11th December, 1880, states that—

4½ tons of ore	...	containing 50 per cent. Bi.
30 „ of rock ore...		„ 5 to 10 per cent. Bi.
30 „ of slimes	...	„ 5 per cent. Bi.

and 2,000 tons quartz, by assay value £4 per ton, were won from the lode during the six months from an open cutting. Samples of native bismuth from this mine shown me weighed from 1 to 2 lbs. Four and a half tons of ore from this mine were forwarded for sale to London. . . ."

In the early part of 1883 these bismuth deposits, which are situated at Kingsgate, near Yarrow Creek, and about 16 miles east of Glen Innes, were geologically examined by Mr. C. S. Wilkinson, whose report* I append almost in full.

"The formations are granite and altered slate, forming rough, broken country, with valleys about 500 feet deep. The line of junction of the two formations is well defined, and the bismuth lodes occur in the granite in proximity to this line or within about 400 yards from it. The mode of occurrence of these so-called 'lodes,' is very remarkable; they are pipe-veins or oval masses of quartz of variable thickness, descending in a more or less vertical direction in the granite, as though well-like caverns of very irregular diameter had been formed in the granite and filled with quartz and metallic minerals. Thus in one lode in the Kingsgate Company's property two masses of quartz (which the manager, Mr. W. Yates, informed me were 30 feet apart at the surface), on being followed down, united and formed one large pipe-vein about 27 feet in diameter, and of irregular shape, from portions of it protruding here and there into the granite. Nests or bunches of bismuth ore (native bismuth, sulphide, carbonate, and oxide of bismuth) were obtained about these protruding portions as well as through the mass of quartz, and in order to take out the vein-stone, a large excavation about 60 feet by 40 feet has been made. The vein has only been sunk upon to a depth of 50 feet. The quartz is of a coarsely crystalline nature, and contains, in patches, a considerable quantity of molybdenite. The metallic bismuth and sulphide occur in the solid quartz, but the carbonate and oxide lie chiefly in the joint fissures in the quartz. Sometimes masses of native bismuth are found between crystals of quartz in the vein, and when removed the impress of the quartz crystals is well shown. Some splendid specimens, from 4 to 6 lbs. weight, from this mine were presented by the Company to the Mining and Geological Museum. . . . The largest mass of native bismuth found here weighed nearly 30 lbs.

"Other similar veins, but smaller, have been proved, though only for a few feet in depth; one contains much arsenical pyrites and hexagonal plates of molybdenite. An average sample of these sulphides gave on assay—

Metallic bismuth, 2·6 per cent.
Fine gold, at the rate of 8 dwts. per ton.
Silver, at the rate of 3 oz. 5 dwts. per ton.

" On portion 25, about half a mile north-west from here, another large pipe-vein is being opened. Near the surface it consists of a very ferruginous mass of quartz, about 13 feet by 9 feet, containing bismuth, arsenical pyrites, wolfram,

*Ann. Rept. Dept. Mines and Agric. for 1882, pp. 27-29; and for 1883, pp. 154-155.

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and molybdenite. The screened vein-stuff is said to yield about 50 lbs. of bismuth ore per ton, which will probably be equal to about 1 per cent. of ore from the whole vein-stuff.

"A sample of the ore consisting of mixed particles of native bismuth, carbonate, sulphide, and oxide, yielded on assay—

Metallic bismuth, 69·3 per cent.
Fine gold, at the rate of 4 oz. 1¼ dwts. per ton.
Fine silver, at the rate of 57 oz. 3 dwts. per ton.

"The result of the assay of the ironstone from this vein was 0·6 per cent. of bismuth, and no gold; and the arsenical pyrites gave only a trace of gold and bismuth, with silver at the rate of 12 oz. 5 dwts. per ton. The gold, therefore, appears to be almost entirely contained in the bismuth ore, probably in the metallic portion of it.

"Several veins of a similar nature have been opened on the Glen Innes Company's property, which adjoins that of the Kingsgate Company. The Company is now sinking upon a vein which is said to have been 1 foot wide at the surface; but when I saw it at a depth of 40 feet (the lowest level then reached), it was 4 feet wide. This vein is in granite, and close to the boundary of the slate formation. The vein-stuff is thickly studded with large brilliant steel-grey plates of molybdenite, some of them being more than 3 inches in diameter. Nodules of native bismuth, larger than walnuts, with carbonate, sulphide, and oxide of bismuth, occur through the vein, and in greater quantity in places where the molybdenite becomes abundant. Another vein, situated about 100 yards from this, contains, besides bismuth ore and molybdenite, some arsenical pyrites, which latter yielded on assay 9·2 per cent. of metallic bismuth, fine silver at the rate of 92 oz. 14 dwts. per ton, and no gold.

"About 3 miles east from the Yarrow Creek head station, and about the same distance in a south-easterly direction from Kingsgate, is the Comstock Bismuth Company's Mine. No work was being done here at the time of our visit; but we saw three pipe-veins of hard white crystalline quartz which had been opened for only a few feet from the surface. The shafts were partly filled with water, so that the exact size of the veins could not be measured; but the largest of them appeared to be about 6 feet by 15 feet near the surface. A sample of bismuth ore collected from the heaps gave on assay—

Metallic bismuth, 35·6 per cent.
Fine gold, at the rate of 2 oz. 9 dwts. per ton.
Fine silver, at the rate of 9 oz. 16 dwts. per ton.

"Thus, again, we see that the bismuth ore contains gold. These veins are also in granite, and distant about 200 yards from the slate formation. It is a somewhat remarkable feature that all the bismuth veins (eighteen) as yet found occur in the granite, within a short distance from the slate; and it is probable that on further examination of the country along the line of junction of the two formations other veins will be discovered."

Molong, 25 miles from.—In 1889 a sample, said to have come from this locality, and consisting of quartz and carbonate of bismuth, gave Bi. 13·05 per cent.

Moor Creek.—See Tamworth.

Mount Dromedary.—A small vein, from a few inches to over a foot in thickness, has for many years been worked on Mount Dromedary. It traverses the granite forming that mountain in a nearly east and west direction. A sample from this vein yielded on assay Bi. 1·66 per cent., Au. 2 oz. 15 dwts. 12 grs., and Ag. 10 oz. 15 dwts. 19 grs.

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Mount Emily, near.—In 1895 a sample of weathered granite from near Mount Emily and to the south of Quambi, containing bismuth ores, yielded Bi. 6·39 per cent., Au. 4 dwts. 8 grs., and Ag. 2 oz. 1 dwt. 9 grs.

Mount Gipps.—An assay was made in 1884 of a brown mineral with cavities filled with carbonate of bismuth, which was said to have come from Mount Gipps, 13 miles north of Broken Hill, in the county of Yancowinna, with the following result:—Bi. 14·55 per cent., Au. nil, Ag. 4 oz. 18 dwts., and traces of copper and cobalt.

Mount Mitchell.—Three samples of ore from this locality were assayed in 1888; two of them, consisting of quartz and carbonate of bismuth, contained respectively Bi. 5·91 per cent. and 1·44 per cent. The third was a concentrated sample and consisted of quartz, carrying native, oxide, and carbonate of bismuth. This yielded on assay Bi. 62·0 per cent., Au. 4 oz. 11 dwts. 10 grs., and Ag. 1 oz. 1 dwt. 16 grs.

These bismuth deposits of Mount Mitchell, near Glencoe, were geologically examined in 1889 by Mr. W. Anderson, whose report* is given almost in full.

"The position of these bismuth-bearing veins is in the north-west corner of the parish of Coventry, county of Clarke, and is about a mile to the south-east of Mount Mitchell. The bismuth ores occur distributed in small irregular patches through a series of quartz-veins averaging from half an inch up to 4 inches in thickness. The quartz is clear and translucent and towards the centre of some of the veins is crystalline, the pyramidal apices of the crystals from opposite sides of the veins interlocking in the centre. The contained bismuth ore is in the form of oxide, sulphide, and carbonate of bismuth, which in many cases are found to cover a central nucleus of metallic bismuth. The veins traverse a ternary granite, whose general texture and mineral constituents vary very much. Their strike is south-west and north-east, and they pass downwards in a nearly vertical direction, with a slight inclination to each other, as if they would unite at a lower depth. Their outcrop can be traced for a considerable distance along the surface, and small quantities of bismuth can be washed from the soil in the immediate neighbourhood of the outcrop. The veins contain a fair percentage of free gold. Little or no work has yet been done in opening up or proving the extent of the bismuth-bearing veins. A couple of holes have been sunk, averaging about 10 feet deep. The mode of occurrence of the bismuth ores here differs slightly from that at the Kingsgate mines, in that at the latter place they occur in pipe-veins near the junction of the granite with the slate, while here they are found in quartz-veins traversing the mass of the granite. Of two assays made of the quartz, one returned 5 per cent. of metallic bismuth, with traces of gold, and the other showed traces of metallic bismuth. . . . It will no doubt be found, on proving these veins, that they are more or less lenticular in shape, thickening and thinning out, and running together in a very irregular manner, although probably on the same vertical line. They do not present, so far as one can judge from their present development, the same prospects of such large quantities of bismuth ore being obtained as in the case of the pipe-veins of Kingsgate."

Nanima.—Auriferous bismuth ores occur in quartz-veins at Nanima, 3 miles east of Murrumbateman in the Yass district. There are several reefs in that locality, some of them 3 or 4 feet wide, which run in a north and south direction and underlay to the east. A sample collected by Mr. E. C. Whittell gave on assay Bi. 6·37 per cent., and Au. 1 oz. 7 dwts.

* Ann. Rept. Dept. Mines and Agric. for 1889, p. 231.

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Nimitybelle.—Bismuth ores were found near Nimitybelle, in the Southern district, in 1888, in which year a sample consisting of quartz and sulphide of bismuth was assayed, and found to contain Bi. 3·67 per cent. An area of 79 acres was taken up with the object of mining for this metal. Since 1888 several samples of the ore, which consist of sulphide of bismuth, with quartz as a veinstone, have been assayed in the D.L., and have given returns varying from 2·71 per cent. to 8·81 per cent. Bi.

Norongo.—Telluride of bismuth was found at Norongo, 8 miles south of Captain's Flat, in 1888, and samples were forwarded to this Department for assay. Two samples, consisting of carbonate of bismuth and tetradymite, were assayed; one was found to contain 19·26 per cent. of metallic bismuth, and the other 27·88 per cent. of bismuth and 10·42 per cent. of tellurium. A third sample consisted of clay, with carbonate of bismuth and tetradymite, and contained 16·9 per cent. of bismuth, a trace of gold, 2 oz. 3 dwts. 13 grs. of silver per ton, and 7·04 per cent. of tellurium. Another sample, consisting of carbonate and sulphide of bismuth, gave 60·2 per cent. of bismuth.

The chemical composition of the telluric-bismuth ores from this locality has been described in some detail by Mr. Mingaye,* who gives the following particulars of the occurrence of the ores:—"The mineral was discovered at Norongo, about 8 miles south of Captain's Flat, in a gossan lode about 16 feet wide, through which runs the vein containing the mineral, the latter being 6 inches in width, and occurring at a depth of about 2 feet from the surface."

The physical character of these ores were described by Prof. David,† who identified the following minerals:—tetradymite, montanite, and telluric-bismuthic ochre. The two latter surround nuclei of tetradymite, and evidently owe their origin to the alteration of the tetradymite.

Nymagee.—In 1895 it was reported that very promising indications of the existence of payable deposits of bismuth were met with in the Nymagee district. No steps have, I believe, been taken to open up these deposits.

Oban.—Two samples from this locality were assayed in 1889; one, consisting of native bismuth, carbonate and oxide of bismuth, gave Bi. 75·60 per cent. and Au. 2 oz. 7 dwts. 21 grs., and the other, a friable earthy carbonate of bismuth, yielded Bi. 10·04 per cent. A third sample was assayed in 1891; this consisted of quartz and felspathic gangue, with molybdenite, and yielded Bi. 1·45 per cent., Au. 4 dwts. 8 grs., and Ag. 2 dwts. 4 grs. These samples may possibly have come from the Mount Mitchell deposits.

Orange.—A sample of bismuth ore, said to have come from the vicinity of Orange, was assayed in 1882, and gave Bi. 5·4 per cent. and Ag. 4 oz. 2 dwts.

Pye's Creek.—In one of the veins on Pye's Creek, in the parish of Annandale, county Clive, bismuth is reported to have been discovered in some quantity. (See Prof. David's Memoir previously referred to.) A 40-acre block next to Hamilton & Co.'s lease was taken up for the purpose of mining for this metal. In 1885 three samples of bismuth, bearing material from Pye's Creek, were assayed with the following results:—

(1) Ferruginous quartz and metallic bismuth from 40-acre block adjoining Hamilton and party's lease gave Bi. 66·8 per cent., and Ag. 33 oz. 8½ dwts.

(2) Ferruginous quartz with metallic bismuth and carbonate of copper from the same locality yielded Bi. 3·9 per cent., and Ag. 200 oz. 18 dwts.

(3) Ferruginous sand and galena and a little carbonate of copper from the same place gave Bi. 13·3 per cent., and Ag. 166 oz. 12 dwts.

* Records Geol. Surv. N. S. Wales, Vol. I, pt. 1 pp. 26-28.
† Records Geol. Surv. N. S. Wales, Vol. I, pt. 1, pp. 29-30.

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Silent Grove.—The Chief Inspector of Mines reported (A.R. 1880, page 220) the existence of a lode 8 inches in thickness at Silent Grove, in the Vegetable Creek district, on the property belonging to Mr. Alexander Stuart, of Sydney. The bismuth lode in this locality occurs under the same conditions as those at Kingsgate, viz., in granite close to its junction with altered slates.

Prof. David, in his Memoir on the Vegetable Creek Tin-mining Field, page 163, mentions that bismuth "has been found native, and as carbonate and sulphide associated with tin-stone and quartz, in portion 15, parish of Silent Grove, county Clive. The total width of the vein is about 1 foot, and its strike 15 degrees south of east and north of west, with a northerly dip. The bismuth is distributed through the quartz chiefly in acicular crystals, and lies next to the foot-wall; the thickness of the bismuth-bearing part of the vein is 4 inches."

Slippery Creek.—Telluride of bismuth was found by Mr. E. C. Whittell, Field Assistant, at Mitchell and Party's claim, near Slippery Creek, in the Oberon district. Mr. Card,* who identified the mineral, writes as follows:—"It occurs along with free gold in small grains and flakes in the quartz, and is associated with greenish and yellowish alteration products. The telluride is probably auriferous."

Solferino.—A sample of brown iron ore from this district near Ewingar was assayed in 1890, and found to contain carbonate of bismuth yielding Bi. 69·95 per cent., and Ag. 2 oz. 5 dwts. 17 grs. Another from the same place, consisting of brown iron ore with a little oxide of bismuth, gave Bi. 0·63 per cent.

Sunny Corner.—Small quantities of bismuth have been found in the ore of the Sunny Corner Mine. An analysis is quoted by Mr. C. S. Wilkinson in his report on that mine (A.R. 1886, page 140), in which 0·88 per cent. Bi. was found in the ore.

Tamworth.—Telluride of bismuth has been recorded from Moor Creek and Sawpit Gully.

Tent Hill.—A sample of decomposed micaceous rock from this locality assayed in 1897 gave Bi. 3·46 per cent.

Tenterfield.—Two samples of bismuth-bearing material were sent in 1879 to the D.L. for assay; one, a yellow ochreous mass, consisting of carbonate and oxide of bismuth associated with quartz and molybdic oxide, stated to have come from Tenterfield, was found to contain Bi. 43·29 per cent., and 6·6 per cent. of molybdenite. The other, said to have been derived from a reef 4 feet wide, occurring near Tenterfield, consisted of metallic bismuth, carbonate of bismuth, and molybdic sulphide and oxide in a matrix of quartz; this yielded on assay Bi. 60·09 per cent., Au. 1 oz. 4 dwts. 10 grs., and Ag. 8 dwts. 10 grs.

In 1889 a sample of quartz with oxide of bismuth gave on assay Bi. 2·72 per cent.; and in the following year a sample of compact felsite with oxide of tin, magnetic iron ore, and a little carbonate of bismuth, yielded Bi. 1·50 per cent.

Tingha.—Samples of bismuth ore have been forwarded from time to time from Tingha for examination. In 1878 waterworn nodules of carbonate and oxide of bismuth, white to dark-brown in colour, were assayed by Mr. Dixon, and found to contain Bi. 60·43 per cent. Rolled fragments of the same, associated with talc and ferric oxide, contained Bi. 62·75 per cent.

Land was taken up in 1885 in the remote south-west portion of the Tingha Division, for the purpose of mining for bismuth ore.

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* Records Geol. Surv. N.S. Wales, 1897, V., Pt. 2, p. 66, Mineralogical Notes by G. W. Card, A.R.S.M.

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Two samples of material, stated to have come from Tingha, were assayed in 1887; one, consisting of quartzite with metallic bismuth, contained Bi. 0·35 per cent.; and the other, an artificially concentrated sample of native bismuth and its oxide, gave Bi. 76·62 per cent. In the following year two more samples from the same locality, consisting of ferruginous quartz, with native, oxide, and carbonate of bismuth, were assayed; one gave Bi. 5·36 per cent., and Au. 13 dwts. 6 grs.; and the other Bi. 1·06 per cent., but no gold.

Uralla.—Telluride of bismuth has been recorded by Mr. Card, from Kentucky Run, near Uralla, where it occurs in association with free gold in a white quartz.

Whipstick.—Rich argentiferous bismuth ores have been obtained in the Great Jingera Silver Mine, which is situated 10 miles west of Pambula and 4 miles east of Wyndham. Mr. Warden Maunsell wrote in 1891 as follows:—"The lodes here consist of soft granular felspar matrix, impregnated with blotches of bismuth, molybdenum, and chloride of silver. They are capped with granitic rock, containing a large percentage of manganese, white mica, and garnets. The country rock consists of quartz, felspar, white mica coarsely crystalline. . . . The Great Jingera Proprietary Silver-mining Company hold eight leases for an area of 203 acres. It is opening up the lode in several places. From an outcrop on mineral lease No. 4 it has despatched 4 tons of ore, averaging 1,170 oz. of silver to the ton, and from 3 to 10 per cent. of bismuth. The mine is situated on the summit of the North Jingera Range, about 1,500 feet above sea-level."

In 1892 the Great Jingera Silver-mining Company sent away to Europe 31 tons of argentiferous bismuth ore, which gave a return of 3½ tons of bismuth, 12 oz. of gold, and 6,107 oz. of silver, of a total value of £2,343.

In the A.R., 1897, page 42, it is pointed out that 1,430 tons of ore were raised during that year, of which 146 tons were sold and exported The estimated value of the bismuth sold was £3,100, and that of the silver associated with the bismuth, £264.

Wyndham.—See Whipstick.

Yarrow Creek.—See Kingsgate.

Production of Bismuth Ore in New South Wales between 1879 *and* 1897.

Year.	Yield.	Value.	Year.	Yield.	Value.
1879 ...	0·40 tons	.....	1889 ...	42·50 tons	£11,349
1880 ...	4·5 „	.....	1890 ...	2·10 „	306
1881 ...	12·5 „	£2,728	1891 ...	0·4 „	500
1882 ...	2·7 „	162	1892 ...	14·0 „	1,080
1883 ...	3·7 „	650	1893 ...	.. ...	... ..
1884 ...	14·37 „	2,770	1894 ...	.....	.....
1885 ...	14·0 „	3,700	1895 ...	.....	.....
1886 ...	20 9 „	3,870	1896 ...	41·0 „	490
1887 ...	36·55 „	6,695	1897 ...	3·1 „	800
1888 ...	18·07 „	3,911			

Sydney: William Applegate Gullick, Government Printer.—1898.

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NEW SOUTH WALES.

DEPARTMENT OF MINES AND AGRICULTURE.

GEOLOGICAL SURVEY.

E. F. PITTMAN, A.R.S.M., Government Geologist.

MINERAL RESOURCES.

No. 5.

REPORT

ON THE

WYALONG GOLD-FIELD.

BY

J. A. WATT, M.A., B.Sc.,

GEOLOGICAL SURVEYOR.

1899.

SYDNEY: WILLIAM APPLEGATE GULLICK, GOVERNMENT PRINTER.

1899.

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GIFT OF
MISS MARIE ROMINGER
AND
MRS. MARK COVILL
25 1937

Geological Survey Branch,
Department of Mines and Agriculture,
21 January, 1899.

Sir,

I have the honor to transmit for publication a report (accompanied by a geological map) on the Wyalong Gold-field, by Mr. J. A. Watt, Geological Surveyor.

The Wyalong Gold-field was discovered in 1893, and it has since been developed so vigorously that it is, at the present time, the most productive field in the Colony. The characteristic lenticular lodes in which the gold was first found near the surface, and which occurred in decomposed granite, have been proved to extend downwards into the undecomposed rock, and to preserve their general character, as well as their productiveness, to considerable depths. The permanence of the field, therefore, appears to be assured.

With regard to the question of alluvial deposits, it is, I think, premature to assert that such deposits do not exist in the neighbourhood, though it is a fact that they have not yet been discovered. The difficulties in the way of finding alluvial leads in such flat country as that surrounding Wyalong are very great, seeing that the surface presents no features that would serve as guides to prospectors. The same difficulties exist in portions of Western Australia, where alluvial gold was not discovered for a considerable time after the lodes had been proved, and where, I feel convinced, many more alluvial leads will yet be found.

There can be no doubt that very extensive denudation of the Wyalong District took place in Tertiary times; the present configuration of the surface supplies proof of this, and further evidence is afforded by the existence of a Tertiary basin, at least 900 feet thick, which exists near the junction of the Murray and Darling Rivers. The average annual rainfall of Wyalong is 13·63 inches, but there is reason for supposing that in Tertiary times the rainfall in Australia was very much greater than it is at the present day. The altitude of Wyalong is nearly 800 feet above sea-level, and I think therefore that there must have been, during the Tertiary period, well-defined channels through which the drainage of this elevated district found its way to the sea, or to the basin or lake just alluded to, the bottom of which is at least 1,300 feet below the present level of Wyalong. In such drainage channels the gold derived from the denudation of the auriferous reefs must have been concentrated, and I venture to think, therefore, that alluvial leads will yet be discovered in this district.

I have the honor to be, Sir,

Your obedient Servant,

EDWARD F. PITTMAN,
Government Geologist.

The Under Secretary for Mines.

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CONTENTS.

PART I. PAGE.

1. The Discovery of Gold at Wyalong 5
2. History of the Development of Mining at Wyalong 7
3. Previous References to the Wyalong Gold-field 9

PART II.

1. Physical Geography 10
2. General Geology: A. General Remarks on the Geology of the District 10
   B. Sedimentary Rocks—
      (*a*) Recent and Pleistocene 12
      (*b*) Silurian (?) 12
   C. Eruptive Rocks 13

PART III.

1. Absence of Alluvial Gold 17
2. The Ore Channels 17
3. General Remarks on the Gold-bearing Veins 17
4. Detailed Description of the Mines 19
5. Genesis of the Deposits 36

PART IV.

Metallurgical Treatment of the Ores 36

PART V.

Other Auriferous Veins in the Vicinity of Wyalong 38

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Report on the Wyalong Gold-field.

By J. ALEX. WATT, Geological Surveyor.

4th January, 1899.

PART I.

1. The Discovery of Gold at Wyalong.

The Wyalong Gold-field has already proved itself so rich and extensive that one naturally feels surprised that it remained so long undiscovered. An examination of the Gold-field, however, at once furnishes us with adequate reasons to account for this delay in its discovery. Among the most important we may mention (*a*) the absence of alluvial-gold deposits; (*b*) the level nature of the ground, and its almost universal covering of red soil; (*c*) the absence of natural supplies of surface water; (*d*) the sparsely-settled condition of the surrounding country; and (*e*) the extremely fine condition of the gold.

The influence of (*a*) will be understood when we remember that alluvial deposits, sometimes extremely shallow, have been found on nearly all the large gold-fields; that these were first found and worked, and that it was only later that the gold was traced to the reefs. The result of (*b*) is that there are very few outcrops of reefs, as these are nearly all concealed by the superficial deposits.

The absence of natural supplies of surface water, and the sparsely-settled condition of this part of the Colony, must have proved almost insuperable obstacles to the prospector.

The influence of (*e*) is evident, for in much of the stone, even where it is rich and the gold is in the free state, it is in such a fine state of division that it can scarcely be detected with the naked eye.

The foregoing facts, as well as explaining the delay in the discovery of this gold-field, show also the amount of credit that is due to the Neeld family for their discovery.

It was not to prospect for gold, however, that Mr. Neeld left Victoria and came over to this Colony; but having made several unsuccessful attempts to obtain a sufficiently large area for selection in the neighbouring colony, he made up his mind to take up land for a similar purpose in this Colony.

With this end in view, one of the sons, then at Hiawatha, near Wyalong, was commissioned to look out for land suitable for settlement in that neighbourhood. As a result, a somewhat small area was obtained at Wyalong, and

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the family came over and settled down on it. The whole of this selection was afterwards resumed, for as mining developments advanced it was found that a large part of the auriferous area was contained within the boundaries of the selection.

Mr. Neeld, who has had considerable experience on the Bendigo, Ballarat, and other Victorian gold-fields, seems to have been impressed by the auriferous indications immediately on his arrival on the 2nd August, 1893. The ironstone nodules and loose fragments of quartz had attracted his attention. No time was lost in commencing prospecting operations, for on the morning after his arrival he tried several dishes of the surface material, but did not succeed in finding gold. Still he persevered, and one morning, about a month after his arrival, the first gold was found. This was in a loose piece of quartz. Several other pieces were found, taken to the camp, crushed, and washed, when a nice trail of fine gold was found in the dish.

The site of this first discovery of gold at Wyalong was on what was afterwards known as the Pioneer Claim. (*See* map.) A fortnight elapsed from the date of this discovery before systematic prospecting operations were started.

As there were practically no outcrops, the method consisted in examining loose fragments of quartz and washing dishes of the surface rubble. In this way the gold was traced gradually up the slight inclines, until no further prospects could be obtained. Near this spot narrow trenches were dug through the soil and rubble into the decomposed granite, until the reef was located.

While Mr. Neeld was prospecting the first discovery, one of his sons found gold-bearing stones just outside the selection, and about ten chains to the east of the former site. The reef from which these stones were derived was soon located. This site was afterwards known as the Dead Rabbit Claim, and later still as the Easter Gift. Later developments proved these two discoveries to be on the same line of reef.

In estimating the difficulties surrounding the prospecting of this part of the gold-field, it must be noted that these early discoveries were made in the midst of thick mallee scrub.

The third discovery was made by Mr. Harry Neeld, who picked up auriferous stone just within the mallee scrub, and on the site now known as Harry's Find. This is on Klink's line of reef, and adjoins Klink's Claim, which has paid large dividends. Harry's Find has remained in the possession of the Neeld family, and has yielded a large amount of payable stone. The next discovery was made on what is now known as the Red Flag Claim. Gold was also found near the site now occupied by the Currajong Mine, but no prospecting was done there. Up to this time shafts varying from a few feet up to fourteen feet deep had been sunk on the various finds.

The most important discovery was made at the end of October, when some of the sons, in going from their camp to the White Tank, found several pieces of gold-bearing stone on the surface of what afterwards became their Prospecting Claim. This site was vigorously prospected, and a shaft 30 feet in depth sunk on the reef.

Now that the field had been fairly well prospected by them they decided to peg out their claims and apply for them.

The pegging-out was done on the 16th December, 1893; first, the Prospecting Claim 960 feet by 400 feet, then Harry's Find as four men's ground; thirdly, the Pioneer Claim, also as four men's ground; fourthly, Christmas Gift as a prospecting claim, and lastly the Dead Rabbit.

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On Monday, 18th December, Mr. Neeld went to Barmedman, reported his discovery, and put in his applications.

Ordinary applications were at first put in, but as the land on which most of the finds had been made formed part of Mr. Neeld's selection, it was necessary to exchange the original applications for applications for permits.

Men began to arrive on the night of 18th December, the day on which the discovery was reported, and by the end of January, 1894, there were about 500 men on the ground.

It was, however, not till March of the same year, when the results of the first parcels of ore crushed at the Barmedman Battery became known, that the big rush took place. By the end of that month about 10,000 people had arrived at Wyalong.

The importance of Mr. Neeld's discovery will be recognised when it is pointed out that in 1897 Wyalong produced more gold than any other mining division in the Colony. The production for that year was 34,370 oz., while Hillgrove, including Metz, which occupied second place, produced 31,886 oz. The total yield from the Wyalong Gold-field since its discovery at the close of 1893 up to the present cannot be less than 130,000 oz., worth more than half a million sterling.

2. History of the Development of Mining at Wyalong.

Ordinary quartz claims only were allowed in the early days of this gold-field. This arrangement gave very satisfactory results for a time, as it prevented the monopolisation of the ground by a few of the first comers, while it led to prospecting operations being vigorously carried on in all parts of the field by parties of working men.

The successful working of this arrangement was in no small measure due to the soft character of the ground, which over almost all parts of the field could be worked with pick and shovel alone down to a depth of at least 150 feet, thus making the sinking of shafts a very inexpensive matter. As a consequence of this many of the reefs have been profitably worked, which had the ground been hard would certainly have been abandoned.

No leases were granted until March, 1896, or more than two years after the discovery of the field. At first, however, the same conditions as to labour were enforced on the leases as on the claims. The object of this was to ensure that the miners already working on the claims should be retained on the leases, and its justification lay in the fact that the sinking was easy, and the leases were mostly still held by working miners.

When, however, the workings reached the hard country rock, and the mining expenses consequently increased, it was decided to allow the old leases to be surrendered and new leases with the ordinary labours conditions to be taken out.

As already mentioned, Mr. Neeld reported the discovery of gold at Wyalong in December, 1893, at which time a shaft 40 feet in depth had been sunk on his Prospecting Claim. There was exposed in this shaft a reef which varied from five or six inches in width at the surface to four feet, and the stone from it was worth from 1 oz. to 1½ oz. per ton.

In the early part of 1894 stone was raised from several parts of the field and sent to the battery at Barmedman for treatment. The results of these first parcels of stone were made known in March, 1894, and caused the big

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rush. I quote from Mr. Slee's report* the results of these crushings, as they are historically interesting. They are as follows :—

Neeld and party	.....	13	tons yielded	26	oz.	4	dwts.
Cassin ,,	.....	12½	,,	9	,,	3	,,
Conway ,,	.....	22	,,	103	,,	5	,,
Keith ,,	.....	28½	,,	67	,,	0	,,
Neeld ,, (No. 2)	.....	17	,,	72	,,	16	,,
Perry ,,	.....	17	,,	42	,,	18	,,
Frazer ,,	.....	10½	,,	39	,,	6	,,
Gorman ,,	.....	37	,,	77	,,	12	,,
Smith ,,	.....	6	,,	8	,,	14	,,
McMahon ,,	.....	4	,,	10	,,	0	,,
Lawry ,,	.....	14½	,,	14	,,	18	,,
Total	.....	181½	tons.	471	oz.	16	dwts.

Thus 181½ tons of stone yielded 471 oz. 16 dwts. of gold, or at the rate of 2 oz. 12 dwts. per ton.

Experience has since shown that rich oxidised stone, as that treated at the Barmedman battery, cannot be satisfactorily treated by this process, and that where such material has been passed through a battery at Wyalong, there has been, almost without exception, a great loss of gold in the tailings. It is, therefore, necessary to point out that the results obtained from the first parcels of stone treated at Barmedman do not in all probability represent the true value of the stone, but that, at least, an ounce to the ton was left in the tailings.

At the end of 1894 the population of the two towns was 4,215. There were 300 claims at work, each consisting of four or eight men's ground. Of these, at least twenty-five were yielding more than payable returns.

During 1894, 6,358 tons of gold-bearing quarts were treated at Wyalong and Barmedman for a total yield of 9,649 oz., or at the rate of 1 oz. 10 dwts. per ton. This does not include the gold contained in the tailings, which, as their treatment later showed, were rich, and, if added, would make up the total contents of the stone treated that year to about 2 oz. per ton.

By the end of 1894 there were six crushing machines at Wyalong. These have since been reduced to four; and two chlorination works were erected, when it became recognised that chlorination was the most suitable process for the treatment of the rich ores.

During 1895 the raising of stone was carried on vigorously, and 15,634 tons were treated for a total yield of 24,497 oz., or an average of 1 oz. 11 dwts. per ton. This return does not include the contents of small parcels sent to Sydney and elsewhere for treatment.

The mine that produced the largest yield during this year was the Currajong, which produced 1,000 tons of ore, yielding 2,620 oz. of gold. During the same year, 1,213 tons from the White Reef Mine gave 2,447 oz.; 318 tons from the Welcome Stranger gave 1,782 oz., and 1,060 tons from the True Blue gave 1,426 oz. By the end of that year shafts ranging from 245 feet in depth downwards had been sunk on the various claims.

During 1896 there were 18,279 tons of stone treated for a total yield of 33,495 oz., or at the rate of 1 oz. 17 dwts. per ton. The deepest shaft at the end of that year was that on the Lighthouse Claim, which had been sunk to to a depth of 310 feet in solid granite. It was sunk to cut Klink's Reef, which, however, was cut at 230 feet from the surface, but not recognised as such at the time.

* Ann. Rept. Dept. Mines and Agric. N.S. Wales for 1894, p. 74.

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The highest yield in 1896 was obtained from Bolte's Mine, now known as the Lucknow, viz., 2,506 oz., from 377 tons of stone, or at the rate of 6 oz. 13 dwts. per ton. From the New South Wales Mine 352 tons were treated for a yield of 2,338 oz.

Neeld's Chlorinations Works were started towards the end of 1896.

The production reached a maximum in 1897, being 34,370 oz. This was derived from three sources, viz., stone, "mullock," and tailings. "Mullock" is the name generally applied to the waste rock which is broken down when the reef is being taken out. In some of the Wyalong Mines, and especially in their upper or oxidised zones, the country rock bordering the reefs is much iron-stained, and often encloses thin veins or leaders of gold-bearing quartz. This is the so-called "mullock" that has been, and is even now being, put through the batteries. Its gold contents vary from a pennyweight or two to half an ounce per ton.

In 1897, 30,750 tons of stone were treated for a return of 33,900 oz., being an average yield of about 1 oz. 2 dwts. per ton, and 4,000 tons of "mullock" yielded 470 oz., or at the rate of nearly 2½ dwts. per ton. About 2,100 miners were employed on the field during the year, and the population was 4,200, or about the same as in 1896.

At the end of 1897 the deepest shaft was on the Lighthouse Claim; this shaft was 504 feet in depth, and is entirely in granite. The following were some of the highest yields obtained during that year:—Currajong Mine, 1,452 oz., from 1,200 tons; Klink's Mine, 1,877 oz., from 275 tons; Shamrock and Thistle Mine, 2,406 oz., from 492 tons; Lucknow Mine, 1,275 oz., from 324 tons; White Reef Mine, 1,264 oz., from 980 tons; and Perseverance Mine, 1,134 oz., from 418 tons.

During the past year, 1898, large quantities of stone and "mullock" have been treated at the different works, and large quantities of tailings at the cyanide works.

Up to the end of September there was treated at Gough's Battery 2,977 tons of stone, which yielded 1,877 oz. 14 dwts.; and 518 tons of "mullock" for 98 oz.; and at West's Battery, 2,438 tons of "mullock" for a return of 371 oz. 3 dwts. At Cox's Mill, up to 20th October, 1,688 tons of stone were treated for a return of 1,150 oz.

Since this report was written the total yield for 1898 has been estimated at 34,582 oz., being 212 oz. above that for 1897.

Developmental work is not being so vigorously carried on at the present time as one could wish. In too many of the mines it has been stopped when the vertical limits of the soft decomposed ground were reached. This is the case even with several of the mines that have yielded rich stone in the easily-worked ground, and have paid large sums in dividends. In many other cases, where the mines have only proved moderately payable, it has been impossible for the holders of the small claims to carry on expensive prospecting operations in the hard ground.

3. Previous References to the Wyalong Gold-field.

In May, 1894, a few months subsequent to its discovery, a geological examination was made of the Wyalong Gold-field by Mr. E. F. Pittman, Government Geologist.*

Two reports were furnished during the same year by the Chief Inspector of Mines.† In addition to the above, annual reports have been furnished by Mr. Warden Clarke for the years 1895–1898. (*See* Annual Reports on this Department for those years.)

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* Ann. Rept. Dept. Mines and Agric. N.S. Wales for 1894, pp. 105–108; and Records Geol. Survey N.S. Wales, IV, pt. 2, p. 107.

† Ann. Rept. Dept. Mines and Agric. N.S. Wales for 1894, pp. 24–25, also pp. 73–74.

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PART II.

1. Physical Geography.

In and around Wyalong the surface of the ground is generally flat, with only a few isolated and widely-separated hills of very moderate height. The Government township of Wyalong stands partly on one of these low elevations, and a second is situated about half a mile to the N.E.

Other low rises occur at Pine Ridge and Pine Hill about 1½ miles S.S.E. of Wyalong.

In the area included in the map accompanying this report there are two main geological divisions; one is occupied by granite, and the other by highly altered sedimentary strata and intrusive hornblendic rocks.

The low hills are practically confined to the latter area, over which the rocks have not been so extensively decomposed as on the granite area. The granite over almost the whole of the gold-field has been decomposed to a mean depth of about 150 feet. The surface over this area is flat, or perhaps, more strictly speaking, is occupied by a flat, shallow depression, with an outlet in the south-easterly portion of the field.

The Wyalong Gold-field is situated within the drainage basin of the Lachlan River, and about eight miles from the water-parting which separates this basin from the adjoining one of the Murrumbidgee River. Wyalong is distant about forty-five miles from the Lachlan River, and about sixty-eight miles from the Murrumbidgee River, and is within a district remarkably free from watercourses. The Government township of Wyalong is sixteen miles N. 35° W. from Barmedman, and forty miles in a similar direction from Temora.

2. General Geology.

A. *General Remarks on the Geology of the District.*

The difficulty of making exact geological observations in the vicinity of Wyalong will be understood when it is explained that with the exception of the few widely-separated low elevations, such as the hill on which the hospital stands to the N.E. of Wyalong township, Pine Hill and Pine Ridge, the underlying rocks are nowhere visible at the surface. They are concealed by a covering of post-tertiary accumulations of red soil, &c., several feet thick. Our knowledge of them is mainly obtained from an examination of the surface soil, which occasionally indicates the nature of the underlying rock, and by openings, shafts, &c., made by miners in prospecting.

The difficulty of geological observation is increased by the absence of any exact knowledge as to the geology of the surrounding districts. In travelling from Barmedman to Wyalong—a distance of eighteen miles—no outcrops of rocks are seen.

In the vicinity of Wyalong there are, roughly, two main geological areas, which can be readily distinguished, and their boundary lines approximately shown. (*Vide* map).

One of these—the larger—is occupied entirely by granite, and in this the large majority of the reefs occur. The other, which seems to contain rocks of greater age than the granite, is occupied by highly altered sedimentary strata, and igneous rocks of intrusive character. The latter appear to vary in composition from intermediate to basic, and are also much altered.

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The total area of the map presented with this report is thirteen square miles, of which more than two-thirds, or an area of about nine square miles, is occupied by granite, and the remaining four square miles by the sedimentary and associated intrusive rocks. The granite area occupies the whole of the western and the north-eastern portions of the map, the other area being confined to its south-eastern corner. The granite extends for miles in a northerly direction beyond the limits of the map, and probably, without a break, as far as Hiawatha—a distance of eight miles, in a direction N. 30° W. from Wyalong. At Hiawatha auriferous reefs have been quite recently discovered in the granite, which is apparently a continuation of the Wyalong mass. The granite also extends for some distance to the south of Wyalong; and westerly towards Yalgogrin the same rock extends continuously for two or three miles, and then in belts alternating with belts of altered sedimentary rocks.

The smaller area appears to be occupied by altered sedimentary strata and intrusive rocks. To what extent either of these exist there it is impossible to say, as over by far the larger portion of this area no exact knowledge of the underlying rocks can be obtained owing to the covering of red soil.

The intrusive rocks consist of diorites and hornblende schists. The latter appear to have been formed through the dynamic metamorphism of the former. A low ridge of these rocks starts near the hospital, and extends in a semi-circular form to the Marsden Road. A second ridge in the south-eastern corner of the map, including Pine Hill and Pine Ridge, is very largely occupied by these hornblendic rocks. Enclosed in the last-mentioned mass of hornblendic rock are three narrow belts of highly altered sedimentary rocks. One of these extends down Pine Ridge in a N.N.E. direction. It is about seven chains wide, and consists of slates and quartzite. A reef extends along the eastern margin of this belt near its junction with the diorite. This belt can be followed for about ten chains down a narrow spur from the main ridge, its further extension being hidden by the superficial deposits of red clay, &c. A second development of sedimentary rocks occurs forty chains to the east of the first; it has a northerly trend, is ten chains wide, and consists of bluish-grey schistose slate.

A third band, whose width is not known, occurs near the Barmedman Road, and twenty chains N.E. of Pine Hill. The order of appearance of these rocks would seem to have been as follows:—In the first place the sedimentary rocks were formed, these were later intruded by the diorites, which became partly converted into hornblende schists, and, lastly, the granite was intruded alike into the sedimentary and diorite rocks.

The deduction as to the granite being of newer age than the diorites is based on the following facts:—

(1.) The close association of the diorites with the oldest rocks—the sedimentary strata.

(2.) The apparently greater metamorphism of the diorites than the granite. The former are frequently found converted into hornblende schist.

(3.) Although the actual junction line between the granite and the diorites is nowhere visible, still in two places small felspathic veins, apparently intrusive, were noticed in the diorite in the vicinity of its junction with the granite. These two dykes are in all probability offshoots from the granite mass, which have been thrust into the diorite.

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B.—*Sedimentary Rocks.*

(*a*) Recent and Pleistocene.

Comprised under this heading are the most recent accumulations, which consist for the most part of red soil, with fragments of quartz and small nodules of ironstone.

Almost the whole area of the gold-field is occupied by these loosely aggregated sandy and clayey materials, which owe their origin largely to the decomposition and disintegration *in situ* of the underlying granite and diorites. The prevailing red colour of these deposits, as of most similarly coloured materials, is due to the presence of larger or smaller quantities of oxide of iron. This is derived from the iron-bearing minerals, biotite and hornblende, which occur in the granite and diorites, and impart to them their dark colour. The decomposition of these minerals sets free the oxide of iron.

This red colour of the surface soil is, perhaps, more characteristic of regions having a dry climate than in moist regions, for in the latter the decaying organic matter has a bleaching effect, due to the reduction of the ferric oxide and its partial removal in a soluble form. Part of the oxide of iron has separated out in the form of small ironstone concretions, which present a rounded pseudo-water-worn appearance, due to their mode of origin. The red colour of the soil is, on the whole, more pronounced and deeper over the area occupied by the diorites and hornblende schists than over the granite area. This arises from the larger percentage of iron in the former rocks.

Angular fragments of quartz are very numerous, especially in the neighbourhood of the reefs. In the absence of well-marked outcrops it was the presence of these fragments that led to the discovery of gold at Wyalong. Small rounded pebbles of quartz occur on the surface in several places. They were particularly noticeable on the mallee flat which extends between the township of Wyalong and Pine Ridge. Although during heavy rain water evidently flows over this flat, there does not appear to be any depth of deposit there or any accumulation of gravel, but the loose rounded stones are scattered irregularly over the surface and through the red soil.

These surface accumulations are sometimes clayey, as on the mallee flats, and sometimes sandy. The sandy portions occur especially on the sides of the gentle slopes, from which the lighter clayey particles have been largely removed by wind and rain.

Besides the concretionary pebbles of ironstone referred to above and known as "ironstone gravel," there are other masses of a concretionary nature which consist of varying proportions of the carbonates of lime and magnesia. These occur especially in the subsoil over the decomposing diorites. The decomposition of the hornblende and felspar of these rocks sets free lime and magnesia, which become readily converted into carbonates by the absorption of carbonic acid gas, which is carried down by rain from the atmosphere. Ordinary hornblende contains about 19 per cent. of magnesia and 14 per cent. of lime. Such concretionary masses were not uncommon in some of the auriferous leads in the Colony where these leads overlay dioritic or andesitic rocks. They occurred at the base of the wash or in the decomposed country of the "bed-rock," and were known to miners as "clinkers."

(*b*) Silurian (?).

There appears to be but a very small development, in the vicinity of Wyalong, of these ancient sedimentary rocks. The existence of three narrow belts has already been noted and their positions described. They

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consist of highly altered sedimentary rocks, schistose slates, and quartzites, which have undergone considerable alteration. No fossil remains have yet been found in any of these sedimentary beds. It is highly probable that all traces of fossils have been obliterated during the alteration of the rocks. In the absence of fossils it is impossible to determine their exact geological age. On other evidence they may be provisionally classed as Silurian. The comparatively recent discovery of Lower Silurian fossils in rocks in two localities in the Colony, viz., at Tomingley, near Peak Hill, and in the parish of Alexander, county of Wellesley, and near the Victorian border opens up the possibility of such strata as those at Wyalong being Lower Silurian and not Upper Silurian, as the practice has previously been to call, provisionally, large areas of rocks in the western portion of the Colony, which, as yet, have furnished no fossil evidence as to their true age.

Some of the sedimentary rocks near their junction with the dioritic rocks contain epidote; the presence of this mineral is evidently due to chemical changes produced by the intrusion.

C.—*Eruptive Rocks.*

To this class belong the granite and diorites. The most important rock, from an economical point of view, is certainly the granite, which contains nearly all the gold-bearing veins worked in and around Wyalong.

The probable extent of the granite, and its relation to the area occupied by sedimentary rocks and the diorites, have already been described.

Along the main lines of reefs the granite has been considerably crushed.

The crushed material of these zones is locally known as the "formation," and the space occupied by it as the "channel."

These local terms will be occasionally employed in describing the reefs.

When seen in mass the granite exhibits a distinctly gneissose appearance. In places near the channel the intense pressure to which the rock has been subjected has produced a distinctly schistose structure. In these cases the rock is sometimes wrongly called by miners a slate. The mineral-bearing solutions, which have circulated through these crushed zones of rock and deposited the minerals of the veins, have produced chemical changes in the granite, which impart to it a dull green colour. The rock so acted upon is frequently called "serpentine" by the miners; to this rock it bears but a superficial resemblance, but differs from it entirely in chemical composition.

The alteration produced by the mineral-bearing solutions extends for some distance into the walls of the lodes, and when met with in deep underground workings is a sure sign of the proximity of a crack or fissure, through which the solutions have travelled. Sometimes in the solid granite a little vein of quartz, perhaps not more than an eighth of an inch in thickness, is bounded on each side by a band of altered rock several inches in thickness. This is the same phenomenon as is met with in large reefs and lodes, where the ore-body is bounded on each sides by a strip of altered rock, usually softer than the unaltered country-rock, but occasionally harder by the deposition of secondary silica.

This alteration is, of course, quite distinct from that almost universally met with in the upper portions of lodes and the surrounding rocks, where water charged with carbonic acid gas, organic acids, &c., percolates through the rocks, and accumulates at a certain level known as the water-level. The effects of this percolation downwards of water from the surface is to soften and decompose the country-rock, and to produce great changes in the mineral contents of the lodes.

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To this must be ascribed the decomposition of iron pyrites in the Wyalong reefs with the production of ironstone and gossan, and accompanied by the setting free of gold in a fine state of division.

The granite has been softened and decomposed over the Wyalong Goldfield to a mean depth of about 150 feet, and down to that level it was capable of being worked by pick and shovel alone.

The undecomposed granite is a medium-grained holocrystalline rock of a mottled grey and black appearance. It has a distinctly gneissose structure, which is especially well-marked in large specimens; the dark constituents, hornblende and biotite, have a roughly parallel arrangement, thus imparting to the rock a distinctly banded structure. Irregular patches, varying much in size and darker in colour than the general mass of the rock, are not uncommon. These, which graduate into the surrounding rock, are apparently more basic in composition, and finer-grained than the rest of the rock.

Such masses are original, and would seem to have become separated out during the cooling of the magma. The minerals present in the granite are felspar, quartz, hornblende, biotite, and in much smaller quantities apatite and epidote.

The following analysis of a typical sample of the rock taken from the Klondyke Mine was made in the Departmental laboratory.

The low silica percentage shows that this rock should be more strictly termed a quartz-mica diorite; but the term granite has been used throughout this paper in its popular sense:—

ANALYSIS.

Moisture at 100° C.	0·13
Combined water	0·73
Silica (SiO_2)	58·93
Ferric oxide (Fe_2O_3)	1·73
Ferrous oxide (FeO)	5·01
Manganese oxide (MnO)	trace
Alumina (Al_2O_3)	17·48
Lime (CaO)	7·08
Magnesia (MgO)	4·33
Potash (K_2O)	1·34
Soda (Na_2O)	2·91
Titanic acid (TiO_2)	0·52
Vanadium pentoxide (V_2O_5)	strong trace
Phosphorus pentoxide (P_2O_5)	0·14
Sulphur trioxide (SO_3)	absent
	100·33

Perhaps the most interesting feature about the microscopic structure of this rock—at least from a mining point of view—is the existence of lines of crushing, along which the quartz is highly crushed, and presents the appearance, almost, of having flowed round the other minerals. The biotite mica is also drawn out and contorted. The analogy between these lines of crushing and the crushed zones, which form the so-called "formation" of the miners, and contain the rich gold-bearing veins of quartz, &c., is evidently very close. Both, in all probability, owe their origin to the same cause, viz., lateral pressure.

A rock whose field-relations to the granite and diorites I was unable to satisfactorily determine is typically developed on the hill on which the house occupied by Mr. Warden Clarke stands. This rock, which has been identified as a norite by Mr. Card, seems to occur as a narrow zone separating the granite from the diorites. The first specimens of this rock were collected previous to my visit, and are said to have come from the hill just mentioned, which is about one mile north of Wyalong Post Office.

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The sections of this rock show it to contain little or no quartz, a very large amount of felspar (plagioclase), and a considerable amount of hypersthene and hornblende. The specimens collected by myself from apparently the same mass contain quartz, felspar (plagioclase), a large amount of hornblende, and perhaps a small quantity of hypersthene.

This rock, therefore, differs in mineral composition from both the granite and the diorites.

An important feature of this rock, and one that seems to connect it with the granite, is the presence in it of veins of coarse pegmatite. These have all the appearance of having separated out before the consolidation of the mass of the rock.

The following is a brief description of the microscopic characters of some of the rocks, which is given for the information of those who are specially interested in this subject.

I have much pleasure in acknowledging the assistance of Mr. G. W. Card, A.R.S.M., Curator and Mineralogist, in the microscopic examination of the rock sections.

*Granite.**—Microscopic sections were cut from four specimens of the rock collected from four different mines. They are: 1889†—Welcome Stranger Mine, 134-foot level; 1888—Lighthouse Mine, 160-foot level; 3,228—Currajong Mine; ——(?)—Gorman's Claim, 225-foot level.

The essential constituents of this rock are felspar, quartz, hornblende, and biotite, and the accessory ones are apatite and epidote.

The felspar appears to be entirely plagioclase, probably oligoclase, no orthoclase or microcline being recognised in any of the slides. The crystals show multiple twinning; in many instances both the albite and pericline types are to be seen in the same individual. Zonal structure is not uncommon, several of the crystals having a core, in which secondary minerals due to alteration are present, surrounded by zones of comparatively clear felspar. This makes it probable that the felspars have been growing *in situ* since the consolidation of the mass. Some of the felspars are shattered, with slight displacement of the portions. Kaolinisation has not taken place to any great extent, and is most marked in the central (? older) portions of some of the crystals.

The hornblende is in part idiomorphic, and the cleavage is well marked in cross-sections. Two varieties of this mineral seem to be present; one usually with idiomorphic outline, and the other more massive, and of a darker colour, and strongly pleochroic, with tints varying from emerald green to a deep blue-green.

The mica, the ordinary dark magnesium variety biotite, is much distorted and bent, and has a disposition to run in bands. Much of the biotite has undergone alteration into a pale green, and even colourless variety, with loss of iron compounds.

Epidote seems to make its appearance as a result of the alteration. Quartz is present, but in distinctly smaller quantity than the felspar. The main feature of this mineral is its crushing. Even in ordinary light the quartz can be seen to be crossed by a number of narrow cracks, but under crossed nicols it almost invariably breaks up into numerous small areas with irregular outline, and accompanied by complete loss of optical continuity.

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* This name is used in its popular sense, but by many petrologists it would be more strictly called a quartz-mica diorite.

† This refers to the number in the official register of rock specimens.

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The crushing has resulted in the production of granular aggregates, which seem to have flowed round the felspars and other minerals. The quartz is the only mineral in the slide which exhibits this intense crushing; the felspars, with their perfect cleavage, contrary to what might be expected, have not suffered to any extent. This is, however, quite in accord with general experience, viz., that quartz is one of the first minerals to disintegrate under pressure.

Apatite and epidote have been mentioned as accessory minerals. The former occurs only in small quantity, and appears in sections as small glassy crystals. The epidote is certainly a secondary mineral, and in the sections is wholly associated with biotite which is in an advanced state of decomposition. It occurs usually in elongated masses of irregular outline, which lie along the cleavage planes.

The epidote is bright yellow in section, is pleochroic, and polarises in very high colours.

Norite.—This is a holocrystalline rock, consisting of plagioclase, hornblende, hypersthene, and magnetite, with also small quantities of biotite and apatite. The plagioclase is the most abundant constituent; it is probably a lime-soda felspar, is very fresh, and shows multiple twinning extremely well, probably on the albite type.

There are numerous inclusions in the felspars, which on the whole have no definite arrangement. The felspars are not shattered, but there are indications of strain. Hypersthene is present as an original constituent; it occurs generally as grains with irregular outlines, but occasionally exhibits prismatic form. The following is a description of this rock, written by Mr. G. W. Card, A.R.S.M., in 1896*:—"The norite is a medium-grained dark-grey rock, having a specific gravity of 2·76, and a silica percentage of 50·60. The minerals present are plagioclase felspar, hypersthene, hornblende, magnetite, zircon, apatite, and probably quartz.

"The felspar, which is fresh and abundant, has not yet been determined. Twinning is almost entirely on the albite type; and the felspar is to some extent schillerized. Hypersthene is very representative, exhibiting the characteristic pleochroism, cleavage, outline and straight extinctions. A paramorphic (?) change to hornblende can be traced step by step from a peripheral fringe of fibrous material to crystals of hornblende containing residual hypersthene, and, by inference, to hornblende in which the transition is complete. There would appear to be a close analogy between the changes here referred to and those described by Williams and Chester in the norites of Baltimore and Delaware respectively. The hypersthene is traversed by deeply-stained cracks. The hornblende is generally green in colour, and exhibits well-developed cleavage cracks when of appreciable mass. It is probably entirely secondary."

Mr. J. B. Jaquet, A.R.S.M., refers† to a similar change in a rock from Kiandra, in which the "majority of the grains (of hypersthene) have partially undergone a paramorphic change, and are fringed with green hornblende."

Other specimens (Nos. 3,235, 3,238, and 3,238 in the Official Register), which I collected from the zone in which the norite occurs, are less basic, and may possibly represent intermediate types between the granite and the norite.

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* Records Geol. Survey N.S. Wales, V, Pt. 1, pp. 13-14.
† Records Geol. Survey N.S. Wales, V, Pt. 3, p. 117.

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All these contain plagioclase felspar, hornblende, quartz, magnetite, and apatite; Nos. 3,235 and 3,233 also contain probably a little hypersthene, and Nos. 3,238 and 3,233 also a little biotite much decomposed.

In all quartz is present in appreciable quantity, and occurs in clusters of grains which have partly rectangular outlines, and polarise simultaneously in a manner somewhat resembling the behaviour of the same mineral in graphic granite.

In regard to the diorites, the sections show that some of the rocks are typical diorites, consisting of hornblende and plagioclase felspar, while others appear to mark stages in the formation of hornblende schist.

PART III.

Economic Geology.

1. *Absence of Alluvial Gold.**

The absence of alluvial gold at Wyalong is one of the most noticeable features of the gold-field, and one in which it differs from nearly all other large gold-fields of the Colony. The existence of so many rich veins at the surface makes it extremely probable that these veins have suffered denudation to some extent. Had the other circumstances therefore been favourable alluvial deposits would have been formed. In the absence of these deposits we must, therefore, conclude they have not been so. The unfavourable circumstances are—

(1.) The absence of hills and gullies, the country being flat, where natural sluicing operations could take place;

(2.) The small rainfall; and

(3.) The exceedingly fine state of division of the gold, which as set free would probably be scattered by the action of the wind and rain storms, which are so frequent in these regions. It is thus probably dispersed through the surface accumulations that cover a large part of the surrounding country.

2. *The Ore Channels.*

Reference has already been made to the nature of the ore channels in the remarks on the granite. The reefs usually occur in a zone of crushed granite; this is a constant feature on the main lines of reef. The width of these zones varies considerably; for instance, on the Mallee Bull line of reef it is as much as eight or ten feet wide in places, and narrows down occasionally to a foot or less. They seem to owe their origin to the force of lateral compression, and resemble shear zones.

3. *General Remarks on the Gold-bearing Veins.*

The gold occurs in a number of veins composed largely of quartz, and, in the upper zone above the water-level, ironstone with sulphide ores below.

The veins occur as a more or less parallel series with a general trend ranging, with one exception, from due N. and S. to 20°, or even occasionally 30°, to the E. of N. and W. of S. They dip easterly at varying angles. The sole exception to the general trend is found in the case of the Pioneer line of reef, which has a nearly due E. and W. trend and a northerly dip.

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* *Vide* introductory letter.—E.F.P.

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There are about a dozen of these lines of reef within an area of about one and a half miles square. Some of the most important of them have received names, as Klink's line of reef, Mallee Bull line of reef, &c.

The reefs are, on the whole, of small size, and may be said to vary in width from an inch or two to a foot or eighteen inches, occasionally becoming as much as three or four feet in thickness.

In many of the mines the mean thickness of the reef cannot be more than eight or nine inches, but in others it may be as much as one foot or eighteen inches. On some of the smaller lines the reef is enclosed by tight granite walls, but usually there is a zone of crushed material, and the reef occurs on either side of this, or even within it. Not uncommonly the reef splits up into several portions, of which one may occur on either foot or hanging wall, and the other somewhere within it. Frequently the crushed granite occupies the whole of the space, and no reef is present.

The veins are lenticular in character, pinching in and widening out very rapidly when followed either horizontally or vertically. Polished surfaces or slickensides are occasionally met with, as well as narrow veins of a black material, consisting of crushed iron pyrites. These phenomena make it clear that some movement has taken place since the formation of the reefs. Polished faces of quartz were noticed in the Klondyke Mine, and grooved and polished masses of iron pyrites in the Lucknow Mine, on which gold is often visible as a thin film.

The largest constituent of the reefs is, of course, quartz; but, especially in the upper zone, calcite and gypsum are also sometimes present in small quantities as gangue minerals.

The metallic minerals in the unoxidised ore consist principally of iron pyrites, with comparatively small quantities of galena and zinc blende, and in the oxidised portion ironstone or hydrated ferric oxide, and sometimes a little carbonate of lead (cerussite) is visible. Native copper with stains of the carbonites are also present in one or two of the reefs.

Quartz occurs chiefly as the white opaque variety, but is colourless and glassy in places. A dull, horny variety was also noticed in one or two reefs.

Opal is also present in the reefs. It is usually of a reddish-brown colour, due to the presence of ferric oxide, but sometimes it is opaque, white, or even occasionally clear and colourless.

In this mineral fairly coarse gold is usually visible. As far as I could learn, it always occurs associated with quartz and ironstone in the upper or oxidised portions of the reefs, and not in the unaltered portions below the water-level. The presence of ferric oxide in this opal, as well as the fact of its being confined to the upper portions of the reefs, point to the probability of its being deposited in the reefs from solutions percolating from the surface. The presence of fairly coarse particles of free gold in the opal is an interesting feature, as the gold in the rest of the oxidised ore, as well as in the sulphides, is in a very fine state of division. If the opal has been deposited from solutions percolating from the surface, the gold has been derived from the same source; its very fine state of division would favour its passing into solution.

The ironstone is evidently derived from the oxidation of iron pyrites, which latter is present in all the reefs below the water-level. The ironstone is often very compact and dense, and is usually very rich. This is so generally rich that stone containing much of it is always treated by chlorination, as experience has shown that a large portion of the gold cannot be saved by the ordinary battery treatment.

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Small quantities of native copper are found in the Klondyke Mine near the base of the water-zone. It occurs chiefly in cracks in the quartz, forming thin, sheet-like masses on the faces of the quartz, from which it may be readily detached.

Below the water-level iron pyrites, galena, and zinc blende occur in the reefs. The two last-named are only present in small quantities. The iron pyrites, on the other hand, is occasionally present in small veins from an inch or two to a foot in thickness, in a fine-grained, compact form. Veins of this mineral with small quantities of galena and zinc blende were being worked, at the time of my visit, in the Lucknow Mine. This ore was very rich, and went in bulk from 20 to 25 oz. of gold to the ton.

The most important constituent of the reefs is the gold. It is almost invariably present in a fine state of division. This remark applies to the ore from both the oxidised and sulphide zones. In the upper or oxidised zone through which surface waters have percolated, converting iron pyrites into ironstone and liberating the gold present in the sulphide ore, the latter is usually so fine that, even in rich ore, it is not readily noticeable except by the aid of a pocket-lens. As an exception to this rule, in one or two mines comparatively coarse gold has been found in the white quartz. This was notably the case in Stanley's Blow Mine, but also to a smaller extent in the Klondyke and Santa Claus Mines.

So closely associated is the gold with iron pyrites in the lower levels in the Wyalong mines that the presence of the latter is an almost infallible sign of their richness.

4. *Detailed Description of the Mines.*

It is now proposed to give a detailed account of the most important mines at Wyalong. The reefs have, on the whole, been found to run in well-marked lines, along which the different mines are situated. There are about a dozen of these lines of reef to be made out; these will now be described commencing from the most eastern one, or Klondyke line of reef.

Where returns from the mines are given, their absolute accuracy cannot be vouched for, as I have had to rely upon the figures given me by mine-owners and others interested in the mines. In the absence of legislation to compel mine-owners to furnish correct statements showing the yields from their mines there are no official records from which this information can be obtained. In many cases the figures given are incomplete. In the case of one of the most important mines on the field, viz., Neeld's Mine, the owners refused to furnish me with the information.

Klondyke Line of Reef.

This is the most easterly line of reef; it has been traced for a length of about fifteen chains, and has been worked principally in the Klondyke Mine. It has been traced northerly into Gatlan's lease, and southerly not beyond M. T. 217, unless a reef, which outcrops near the eastern boundary of G. L. 37, and which is being prospected by the United Australian Exploration, Ltd., is a continuation of it.

Klondyke Mine.—This is the only mine of any importance on this line. It is owned by Mr. Tyler. The reef in this mine, which has been opened up to a depth of 260 feet, is one of the few examples on the field of a true quartz reef, consisting, as it does, of a vein of quartz filling a fissure in the granite and bounded by well-marked walls. It strikes in a direction 30° E. of N.

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and W. of S., and underlies at a steep angle to the east. In the last 100 feet, viz., between the 160- and 260-foot levels, the reef is practically vertical. Water was met with at 140 feet from the surface.

In the northern end of the mine there are two reefs above the 160-foot level, which junction at that level and extend downwards as a single reef. The eastern of these two branches dips at an angle of about 1 in 3, while the western one is nearly vertical. In the southern part of the mine there is a single reef down to 220 feet, where it splits into two portions. The accompanying section in the plane of the reef (fig. 1) shows a rich shoot of

Klondyke Mine.

Section along reef.

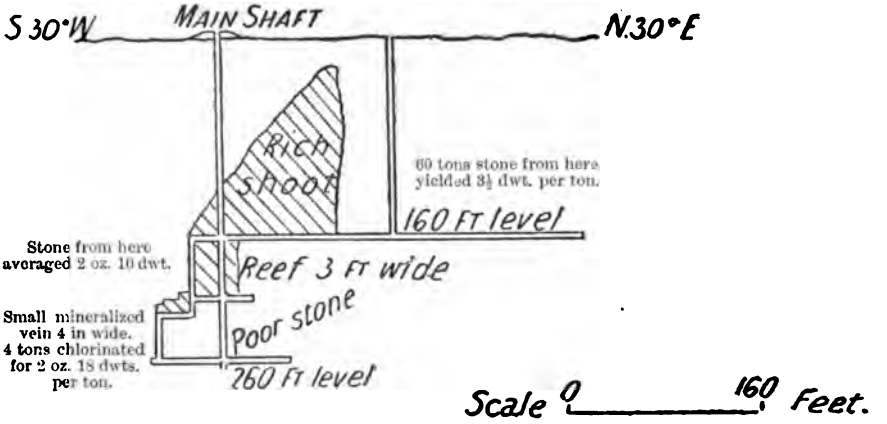
S 30° W
MAIN SHAFT
N.30° E
RICH SHOOT
60 tons stone from here yielded 3½ dwt. per ton.
160 FT level
Stone from here averaged 2 oz. 10 dwt.
Reef 3 FT wide
Small mineralized vein 4 in wide. 4 tons chlorinated for 2 oz. 18 dwts. per ton.
Poor stone
260 FT level
Scale 0 160 Feet.

Fig. 1.

stone 120 feet long at the 160-foot level. This shoot has not yet been located at the 260-foot level. Immediately below the 160-foot level and north of the shaft, a reef 3 feet wide was exposed, the stone from which was expected to yield at least 2 oz. to the ton. At the bottom level north of the shaft the drive has been put in along stone of poor quality. In the roof of this drive native copper could be seen in the quartz; this was apparently always in the form of thin plates filling up somewhat rectangular cracks in the quartz. One piece given me by the manager is rectangular in shape, the two sides being about an inch in length and about an eighth of an inch in thickness.

The manager is strongly of opinion that the metallic copper was an unfavourable feature, and expected that when the copper disappeared the quality of the stone would improve. It may be so, but it is not clear how the presence of metallic copper could influence the gold contents of the stone.

In the south drive at the 260-foot level fairly good stone was met with, but the vein became split up. From one small vein about four inches in width, and carrying a fair amount of iron pyrites, four tons were taken and chlorinated for a return of 2 oz. 18 dwts. per ton.

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The prospects of this mine are distinctly good, for the reef is a strong one, being one of the widest bodies of quartz in the Wyalong District, is well-defined, and should extend down to a considerable depth.

In 1897, 263 tons of stone were treated from this mine for a yield of 432 oz.

Gatlan's Lease.—The Klondyke reef has been traced into this lease (G. L. 47), and stone taken from it near the boundary is said to have been crushed for a return of 16 dwts. per ton. Near the north end of this ground a shaft has been sunk to a depth of eighty feet, and the reef was cut at the 50-foot level by a short crosscut. The reef there appeared to be of little value, being represented by a narrow band of crushed and decomposed granite. A small reef has been cut two chains west of the Klondyke line in this end of the ground. It is very small, and no stone has been raised from it.

Miner's Right M. L. 102.

This is about twenty-two chains nearly due north of the Klondyke Mine. The reef runs in a N.E. and S.W. direction, and is nearly parallel to the Klondyke reef. It has been worked intermittently for some time, but was practically abandoned at the time of my visit, on account of the low yield obtained from the last parcel of stone treated, viz., 40 tons for 11 oz., or at the rate of 5½ dwts. per ton. The reef is only a short one. A northern extension of it was worked in the mine known as Irwin's Blow, and 32 tons from it were treated at Barmedman for a return of 3 or 4 dwts. per ton.

Shamrock Mine.

Another short reef occurs in this mine. This reef, which was discovered by Mr. S. Hennessey, is approximately parallel to the Miner's Right and Stanley's Blow reefs, and is six chains W. of the former, and four chains E. of the latter. It strikes about N.E. and S.W., and dips to the S.E.

About two years ago 16 tons of stone were raised from this reef, and yielded 3 oz. 14 dwts. per ton. This was taken from a lenticular patch about 60 feet long, and varying from 6 to 18 inches in width. The first crushing of 9 tons taken from near the surface contained some coarse gold, and yielded 2¼ oz. per ton.

The deepest shaft on this reef is 150 feet. Two men went into this mine recently with the object of removing the so-called "mullock" from the old stopes, but found it to be too poor.

Stanley's Blow Line of Reef.

The main workings on this line are thirty-five chains north of the Klondyke Mine.

To the north this reef splits up into two portions, which in Summergill's lease are about forty feet apart. To the south-west of Stanley's Blow the reef seems to continue on, but has not been worked to advantage. This line of reef was first found in Stanley's Blow Mine, where a large massive outcrop or "blow" of white quartz marked its presence at the surface. The greater part of this "blow" has been removed and crushed, and yielded fair returns; some of it contained coarse gold, the particles ranging in size up to that of grains of wheat.

Stanley's Blow Mine.—In this mine the reef averages about two feet in width, but it occasionally widens out to four feet. Several shafts have been sunk on the reef, the deepest being 190 feet.

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Between 400 and 500 tons of stone have been crushed from this mine, of which 160 tons yielded at the rate of 6¾ dwts. per ton; 100 tons gave 8 dwts. per ton; 80 tons, 6½ dwts. per ton; and 45 tons, 7 dwts. per ton.

Recently the mine has been worked on tribute; the tributors have taken out about 43 tons, chiefly from the vicinity of the surface, which yielded about 7½ dwts. per ton.

Summergill's Lease.—Stanley's Blow reef is represented by two reefs in this mine. The two reefs are 40 feet apart. A crosscut from the bottom of the 150-foot shaft, sunk between them, intersects the western reef fourteen feet from the shaft. This reef varies from six to twenty inches in width, and 60 tons raised from it yielded 1 oz. 8 dwts. per ton.

A similar amount raised from the eastern reef gave 1 oz. 4 dwts. per ton.

Klink's Line of Reef.

This line crosses the road, connecting Wyalong and West Wyalong, about thirty-six chains west of the Klondyke Mine.

Gold was first discovered on this line of reef on the claim known as Harry's Find. Very good stone has been taken from this claim, but the mine that has produced by far the largest amount of gold is the one adjoining Harry's Find on the north, viz., Klink's.

This, which in the early days of this gold-field proved one of the richest lines, has not been traced with any certainty more than twenty chains. Its general strike is N. 10° E. and S. 10° W., and its dip is easterly. For a short distance the strike is nearly N.E. and S.W., and in the north end of Klink's Mine it seems to have taken a course somewhat west of north.

As on most of the other lines of reef, there is no well-marked outcrop, but below a foot or two of red soil it has been traced through Klink's Claim, where it is about seventy feet from the western boundary, through the centre of Harry's Find into the N.W. corner of the Victoria, and S.E. corner of the Frenchman's, and finally into the Catherine.

It has been doubtfully picked up in the adjoining claim to the south.

North of Klink's Mine the reef has not been followed, but in the adjoining claim, the Star of the East, two reefs have been found, either of which may be a continuation of Klink's reef.

N.N.W. of the Star of the East is the Ethel D., in which a band of crushed country "formation" has been met with. It is thought by some that this is a continuation of Klink's line of reef, but there is no evidence to show whether it is so or not.

The following mines were at work on this line of reef at the time of my visit, viz., New South Wales (the name applied to the two amalgamated mines formerly known as Klink's and Lighthouse), Harry's Find, Victoria, and Prince of Wales. In several others work had previously been done, but they were then idle; these are Star of East, Frenchman's, Catherine, Grand Junction, and Princess.

New South Wales Mine.—This includes the mines formerly known as Klink's and Lighthouse.

In the former mine (Klink's) the reef has been worked from the surface to a depth of 170 feet, and the ore obtained from it has been very rich. In the southern end of the mine the reef dips out of this ground into the Prince of Wales Mine, and in the northern end into the Lighthouse.

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At about a depth of 170 feet from the surface there is a sudden change in the angle of dip of the reef (see fig. 2). From the surface to 170 feet the mean dip is about 45°; from that depth to where it was cut in the Lighthouse shaft the mean dip is as low as 17°. There was a very rich reef in this mine from the surface to 170 feet; from that depth downwards into the Lighthouse

New South Wales Mine.

Section across Klink's Reef.

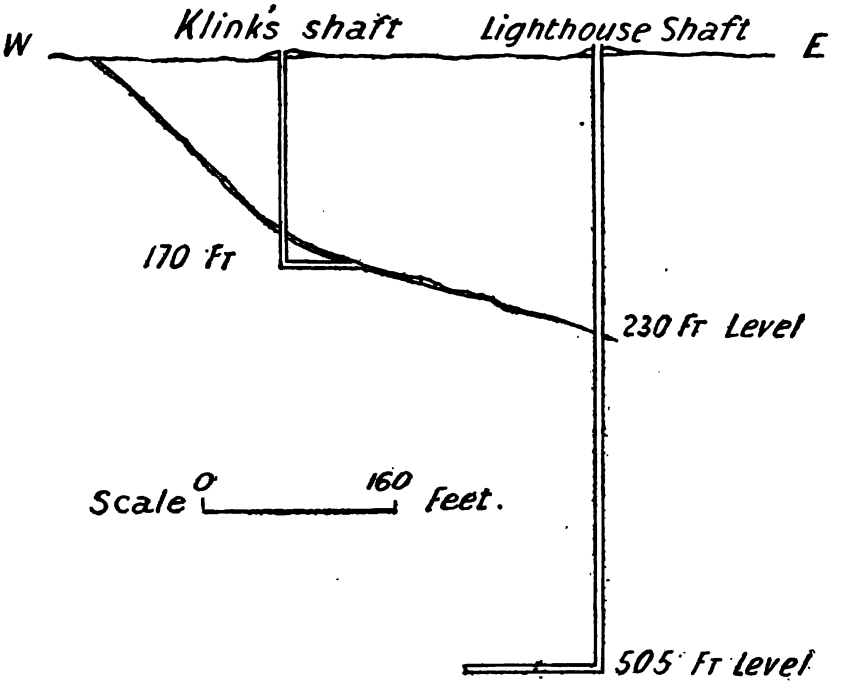

Fig. 2.

shaft no payable stone was met with, the reef between those two places being represented by a narrow zone of crushed and altered granite, with narrow lenticular bands of quartz. I regret my inability to get reliable information in regard to the returns from this mine, as it has been in the past one of the best dividend-paying mines on this gold-field.

Two parties of tributors were raising "mullock" from the old stopes in this mine. One party took out 218 tons of this material, which yielded 8 dwts. 19 grs. per ton, and 140 tons, which gave 5 dwts. 20 grs. per ton.

On the Lighthouse Claim a shaft was sunk to cut Klink's reef. This shaft has been sunk to a depth of 505 feet. A narrow band of crushed country was passed through at 230 feet from the surface; but as it was expected that the reef would not be cut in this shaft before a depth of 400 feet was reached, no notice was taken of this band. Later, Klink's reef was found to be continuous with this band met with at 230 feet, the reef having suddenly become very flat.

Between the Lighthouse shaft and the 200-foot level, in Klink's Mine, the reef appears at intervals, and is occasionally as much as a foot in thickness. But in many places no reef is visible, the channel being entirely

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occupied by crushed granite. Levels were put in near the Lighthouse shaft, and 50 tons of quartz were raised from a reef, which averaged about 4 ins. in thickness.

The stone yielded 10 dwts. per ton, a return that was not payable, by reason of the small size of the reef and the difficulties of working it.

It is still thought probable by those interested in this property that the flat reef cut in the shaft at a depth of 230 feet is not the main reef, but that another will be found much steeper in dip, which was not cut in the shaft. In support of this view, they point out that at the bottom of Klink's 170-foot shaft, where the reef as exposed suddenly flattens, the country is much disturbed, making it possible that the main reef has been missed in this disturbed country, and that what has been followed is only a flat offshoot. It is also pointed out that in the Star of Peace Mine two reefs were found, of which the western one had a much steeper dip than the eastern.

I saw no evidence of a second reef. This point will shortly be decided, for a crosscut to the west is being put out from the bottom of the 505-foot shaft.

This had been extended more than one hundred feet at the time of my visit, and no reef had been cut; another twenty or thirty feet more should definitely settle the question.

Harry's Find.—This adjoins Klink's on the south; it was originally taken up by the Neeld family, and has remained in their hands ever since.

The reef has been worked by tributors down to the 150-foot level, where it passes into the Prince of Wales lease.

The shoots of rich stone in this mine dip apparently to the north.

Victoria Mine.—This is on the south side of Harry's Find. The outcrop of the reef passes through the N.W. corner of the claim. Its general strike is nearly due N. and S., and its dip is easterly. The reef in this ground is very flat, dipping at a mean angle of about 30° between the surface and the 160-foot level. It varies in thickness from an inch or two to two feet, and averages about nine inches. Very good stone was obtained near the surface in the northern end of the ground; but at the southern end no stone of any value has been obtained below eighty-five feet. The reef below that level is a foot or more in width, and consists of hard white barren quartz highly charged with black oxide of manganese. Normal faulting on a small scale was visible in several places in the mine.

Prince of Wales Mine.—This mine is on a block claim adjoining Klink's and Harry's Find on the east. The original shareholders were Messrs. Sladen and Naylor, by whom the ground was taken up. The property passed into the hands of the present owners, the United Australian Exploration (Ltd.), in June, 1897, who are reported to have paid £4,000 for it. Mr. A. S. Boucher is the superintendent engineer, and Mr. J. Gunther, the manager. There are two working shafts; a main one, which is vertical to a depth of 275 feet, cut through the formation at 225 feet. The other shaft, sunk near the S.W. boundary of the ground, is vertical to 175 feet, and then follows the underlay a further distance of 285 feet. Owing, however, to the extreme flatness of the reef, the vertical depth gained by sinking the last 285 feet on the underlay is probably not more than 80 feet.

Levels have been opened up at 225 feet from the surface. The reef along this level varies from an inch or less to a foot in thickness, and averages about five or six inches. In many places no reef can be seen, only a line of fracture, with more or less shattered granite in it. The general strike of the reef at this level is N. 10° E. and S. 10° W., and the mean dip from the bottom of the 175-foot shaft to the lowest point reached cannot be more than 17°. In places the reef is quite flat.

There are about twenty tons of rich ore and ninety tons of second-grade ore at grass.

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Santa Claus Line of Reef.

This line of reef is distant about six chains west of that just described, and, like it, has produced large quantities of rich stone. It has been traced for a distance of about forty-five chains. Its general trend is N. 17° E., and its dip is easterly.

The following mines are situated on it, viz.:—Santa Claus, Aladdin, Erin's Isle, Monte Christo, Shamrock and Thistle, Waratah, and Ante-up. Of these, by far the most important is the Shamrock and Thistle.

Santa Claus Mine.—This was one of the original discoveries of the Neeld family. The reef is small, and does not average more than 4 or 5 inches in thickness, and occasionally splits up into several smaller veins. Some beautiful specimens of coarse crystalline gold were found in vugs in a dense grey quartz at the 128-foot level, which is the greatest depth at which work has been done in this mine. A total of 443 tons of stone have been raised from this mine between the surface and the 128-foot level, and been treated for a total return of 680 oz., or at the rate of 1 oz. 11 dwts. per ton. The best return was from a parcel of 6 tons, which yielded 42 oz., or 7 oz. per ton.

There was practically no work being done at the time of my visit in the Aladdin, Erin's Isle, and Monte Christo Mines. They have all been worked down to the water-level, or about 150 feet, and the two last-named are said to have yielded fairly large quantities of payable ore.

Shamrock and Thistle Mine.—This was formerly known as Conway's Mine, after the name of its discoverer. Rich stone was met with in this mine at the very surface, and a rich shoot of ore has been worked continuously to the 230-foot level, and has been picked up at the 330-foot level (see figs. 3 and 4).

Shamrock and Thistle Mine.

Section along reef.

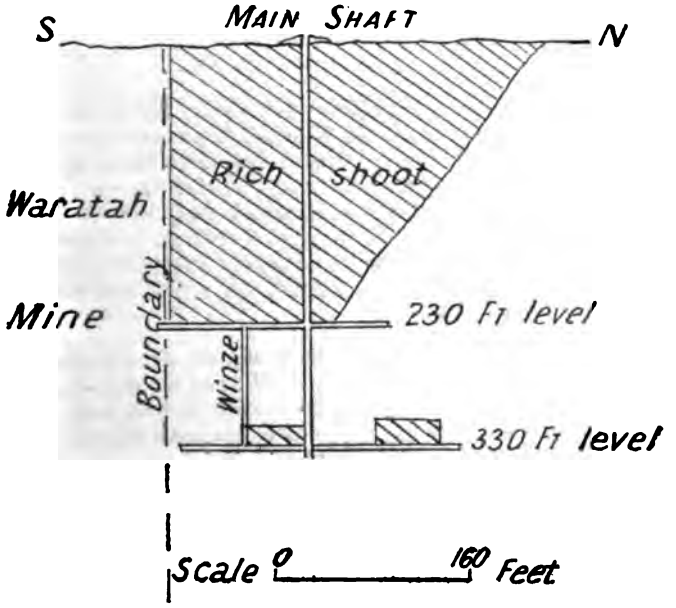

Fig. 3.

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The mean dip of the reef between the surface and the 330-foot level is about 60°. Between the surface and the 230-foot level the ground has been worked out, but between that and the 330-foot level it has not been opened up to any extent. A winze fifty feet north of the shaft, connecting these levels, is said to have passed through good stone. In the bottom level

Shamrock and Thistle Mine.

Transverse section across reef.

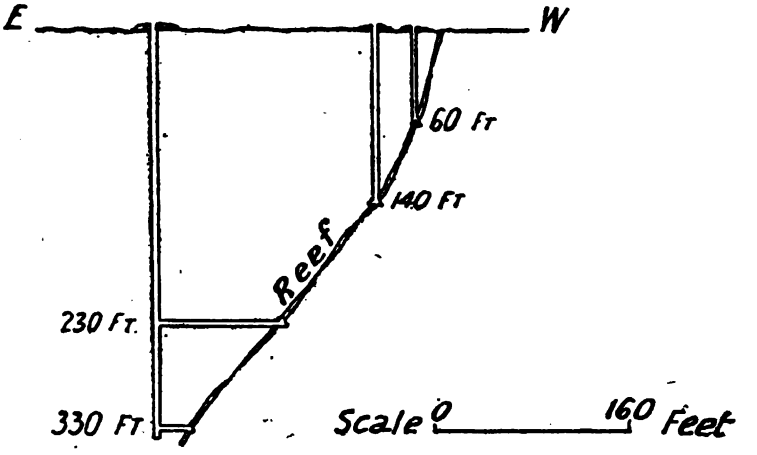

Fig. 4.

the rich stone seems to extend fifty feet south from the shaft, but a further thirty feet driven towards the Waratah boundary has exposed no reef of any importance. In the north drive, at the same level, no reef was met with for a distance of fifty feet from the shaft, but for the remaining sixty feet the drive passes through a highly mineralised reef, nine or ten inches in thickness. This stone is expected to yield 5 or 6 oz. to the ton. The rich mineralised ore from this level consists of glassy quartz, highly charged with iron pyrites and small quantities of galena. A sixth interest in this mine was recently sold for £1,750.

Waratah Mine.—This mine adjoins the Shamrock and Thistle on the south. The strike of the reef is N. 7° E. and S. 7° W., and the dip is easterly. The average width of the reef is about four or five inches, but occasionally it widens out to three feet. Some rich stone has been raised from this reef between the surface and the 215-foot level.

Ante-up Mine.—This adjoins the Waratah on the south. A rich shoot of stone was met with about forty feet above the 160-foot level (see fig. 5). The reef is small, like most of the reefs of this gold-field. This mine has produced 253 tons of stone, which yielded 546 oz. of gold, or at the rate of 2 oz. 3 dwts. per ton. The best return was obtained from 6 tons 14 cwt. of stone, which gave 8 oz. per ton.

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There is a short line of reef running about midway between the Santa Claus and the Mallee Bull lines, on which the Young Australia Mine is situated. The reef in this mine has been sunk on for a depth of 230 feet. In the

Ante-up Mine.

Section along reef.

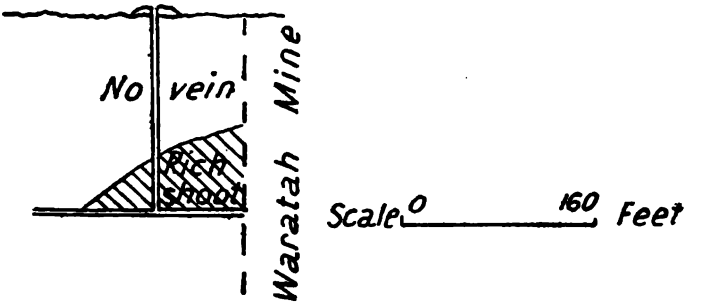

Fig. 5.

bottom it is well defined, and dips at an angle of about 80 degrees to the east. The returns from this mine are 103 tons of stone, for a yield of 163 oz., or at the rate of 1 oz. 12 dwts. per ton. Some of the stone yielded as high as 6 oz. per ton.

Mallee Bull Line of Reef.

This is undoubtedly the most important line of reef in the Wyalong Gold-field.

This line crosses the road connecting the Government township of Wyalong from West Wyalong, about one and a-half mile west of the Wyalong Post Office. It has been worked at intervals for a length of nearly one hundred chains, and on it are situated the richest mines of the field. It apparently gives off at the surface two important branches, one in Neeld's Prospecting Claim and the other in the True Blue Mine. The general strike of the main reef is N. 20° E. and S. 20° W., and its dip is easterly. The reef does not extend continuously from one end of the line to the other, for there are gaps where no reef is visible. What does persist from one limit to the other is the zone of crushed and altered country rock locally known as the formation. This can be traced throughout, and in some of the mines where a regular quartz reef has not been met with, as in the Brilliant, this zone is strongly developed, and often from six to eight feet wide. The average thickness of this reef is approximately about fifteen or eighteen inches. It widens out to two or three feet occasionally, and in one or two places to six feet or more, but it pinches in often to a few inches.

As to the value of the stone, it is as variable as the width. The richest ore has been obtained from the Lucknow Mine, from which bulk samples have been raised which have yielded as much as 25 oz. of gold to the ton.

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From other portions of the reef along the line returns as low as 2 or 3 dwts. have been obtained. It is a pretty general rule along this line of reef that where ironstone or iron pyrites occurs in the stone in large quantities the stone is sure to be rich. The richest ore, viz., that from the Lucknow Mine, consisted of solid iron pyrites. As might be expected, the pyrites from the different mines, though usually rich, varies considerably in value; thus some fragments from the Lady Hampden Mine, which resembled the 20-oz. stone that was being raised in the Lucknow Mine, on being assayed were found to contain only 3 oz. 14 dwts. per ton.

Of the two principal branches given off from the main reef, the northern one leaves it about the middle of Neeld's Prospecting Claim, and extends for about ten chains in a north-easterly direction into the Lady Grace Claim. The other branch breaks away from the main reef in the True Blue ground and extends for at least twenty chains in a nearly due south direction.

On this latter branch the Junction Mine is situated.

On the main line of reef are Neeld's Mine (the prospector's), and to the north of this the Bantam, Lucknow (formerly known as Bolte's), Daisy, and Ironbark Mines; and south of Neeld's are the Lady Hampden, Brilliant, Mallee Bull, True Blue, Grand Central, Mallee Cow, Empire, Perseverance, Ledger, and Maiee Mines.

Of these, the most important are Neeld's Lucknow and True Blue Mines.

Gold was discovered on this line first in Neeld's Prospecting Claim; this has proved to be the most important discovery made by the Neeld family at Wyalong. This line of reef has been the most productive on the gold-field, and there is every probability that it will prove the most permanent.

Neeld's Mine.—This mine is, perhaps, without exception, the richest on the gold-field. The general strike of the reef is about N. 12° E. and S. 12° W., and the dip is easterly about 70°. A main vertical shaft was sunk to the east of the outcrop; this is forty feet east of the reef at the 100-foot level, and fifteen feet east of it at the 200-foot level. The sinking of this shaft was being proceeded with. In the vicinity of the underlay shaft, which is four chains south of the main shaft, a branch comes off from the main reef and extends in a north-easterly direction into M. T. 103, lately known as the Lady Grace Claim. This branch has been worked down to a depth of 160 feet chiefly by tributing parties of miners. At the 200-foot level, the main reef, which is there about two feet wide, is separated by twelve or thirteen feet of more or less crushed granite from a small reef a few inches in width. At thirty-five feet south of the crosscut a small vein branches off from the main reef and traverses first a S.W. and then S. 15° W. direction. A drive sixty feet in length has been put along this branch, which varies from a few inches to a foot in width, and consists of hard, white quartz, which assays up to 1½ oz. per ton. Near the northern end of the mine rich stone has been obtained from the surface down to the 100-foot level; this yielded from 2 to 15 oz. per ton, and averaged 4 oz. per ton. In the stopes above the 200-foot level in this end of the mine a reef which was as much as five or six feet wide in places was being worked, and very rich stone was being raised from it. In the southern end of the mine the ore seems to be on the whole much poorer, and was being partly worked by tributors; but in this end of the mine a rich shoot of ore was being opened up at the 200-foot level at the time of my visit. More than 2,500 tons of stone were at grass, which would yield from 8 dwts. to 10 or 12 oz. to the ton.

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The accompanying section (see fig. 6) along the line of reef in this and adjoining mines to the north shows the approximate size and positions of the

Mallee Bull Line of Reef.

Section along line of reef in Neeld's Prospecting Claim and Bantam and Lucknow Mines.

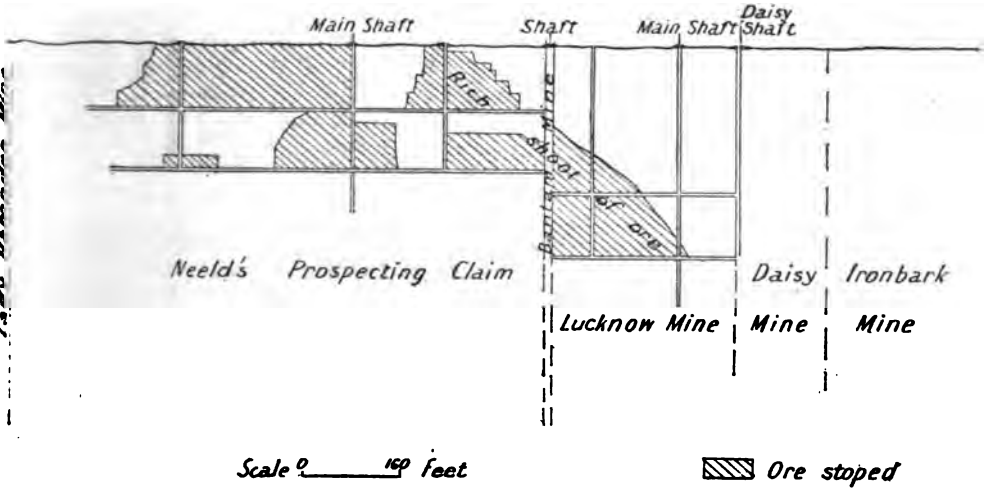

Fig. 6.

ore-bodies as at present exposed in these mines. The rich shoot of ore worked in the north end of Neeld's Mine appears to be dipping to the north, and to be continuous with that worked in the Bantam and Lucknow Mines.

Bantam Mine.—This is only a narrow strip of ground, seventeen feet wide, which separates Neeld's from the Lucknow Mine. It has lately been amalgamated with the Lady Grace, which is a block claim on the east, and into which the reef will probably extend at a depth. The amalgamated properties are now known as the Bantam Proprietary. A shaft has been sunk on the Bantam 406 feet in depth; for the first 125 feet it is vertical, and on the underlay for the remainder of the distance.

This mine has been in the hands of the present owners only since the beginning of this year; they paid £750 for it. Between February and August of this year £4,400 has been taken out of the mine, and £2,500 paid in dividends. About £2,000 has lately been spent in equipping the mine with haulage machinery and in cutting down the shaft.

Lucknow Mine.—This mine adjoins the Bantam on the north. A vertical shaft has been put down to the east of the outcrop to a depth of 336 feet.

The rich stone was not met with in this mine until a depth of 180 feet had been reached. At the time of my visit the payable stone had been worked out between the surface and the 236-foot level, but very rich stone was being raised from the stopes above the 336-foot level. This rich stone extends from the main shaft south to the Bantam boundary.

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Some very valuable parcels of ore have recently been sent to Dapto from this mine. Of one parcel of 52 tons, 25 tons of first-grade ore yielded 23 oz. 13 dwts. per ton, and 27 tons gave 8 oz. 1 dwt. per ton.; of another parcel of 45 tons, 15 tons yielded 22 oz. 4 dwts. per ton; 7 tons, 7 oz. 1 dwt. per ton; and 23 tons, 4 oz. 13 dwts. per ton.

From the beginning of 1895 to October, 1898, the following returns have been received:—

tons	cwt.				oz.	dwts.	grs.
171	2	treated at Clyde Works, for	.....		791	5	0
5	4	,, Footscray	,,	.....	48	18	13
12	1	,, Wallaroo	,,	.....	173	0	0
23	6	,, Bendigo	,,	.....	80	0	0
187	16	,, Ballarat	,,	.....	1,473	7	0
17	18	,, Climo's	,,	.....	126	9	11
366	10	,, Dapto	,,	.....	2,894	3	11
Total ...783	17		,,		5,587	3	11

In addition to the above, 895 tons of lower-grade material were treated at the local batteries for a total yield of 639 oz. 16 dwts.

During the same period this mine has paid in dividends the sum of £12,545.

Daisy Mine.—This adjoins the Lucknow on the north. A shaft has been sunk close to the Lucknow boundary to a depth of 340 feet, and is vertical for the first 100 feet and on the underlay for the remainder of the distance. No reef of any value has yet been met with.

At the 300-foot level a drive was put in to the north on a very narrow vein, from which half a ton of stone was obtained, of the value of 6 oz. to the ton. The shaft is being sunk in a crushed zone of country rock 3 to 4 feet wide. An important point in the future prospects of this mine is the possibility of the rich shoot of stone now being worked in the Lucknow Mine dipping northwards into the Daisy.

It will be seen from the section previously referred to that the northern boundary of this rich shoot appears to be dipping to the north. If this dip is maintained, and the shoot continues downward, it should be met with in the Daisy Mine at from 100 to 150 feet below the present level of the Daisy shaft.

Ironbark Mine.—In this, which adjoins the Daisy on the north, the existence of two reefs has been proved. The deepest shaft is 251 feet in depth. At the 200-foot level there is a strong formation, which is as much as six or seven feet wide in places. At the 80-foot level there is a reef at least two feet wide, but the stone is of very low value. Twenty tons of stone were raised from near the surface, and yielded about 5 dwts. per ton. This seems to be the average value of the stone opened up in this mine.

This line of reef has not been traced any further to the north.

Lady Hampden Mine.—This, which includes only a narrow strip of ground along the line of reef, adjoins Neeld's Mine on the south. The reef was cut in the shaft at 100 feet, and followed down to a depth of 204 feet. It was thought by the managers of this and the adjoining mine, the Brilliant, that the workings in these two mines were probably not on the Mallee Bull line, but on a branch from it. Until Neeld's reef has been traced into the Lady Hampden Mine it will not be possible to say whether this is so or not; but I am inclined to think they are on the main line. From this mine 128 tons of stone have been raised and treated for a total return of 79 oz. 5 dwts., or at the rate of rather more than 12 dwts. per ton. The stone has varied in

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value from 4 dwts. to 2 oz. per ton. A sample of pyrites brought down by me for assay gave a return of 3 oz. 14 dwts. of gold per ton, and 3 oz. 0 dwt 23 grs. of silver per ton.

Brilliant Mine.—This mine includes the claims formerly known as the Brilliant and the Treasure. Prospecting operations have been carried on with remarkable perseverance, although up to the present no payable stone has yet been met with. A shaft about 400 feet in depth has followed down the zone of crushed granite, which varies from three to eight feet in width. Lenticular masses of practically barren stone have been met with, and some pieces of stone showing free gold were found in the bottom of the shaft; but they did not resemble the rich stone found in the other mines on this line.

Mallee Bull Mine.—A large amount of work, both sinking and driving, has been done in this mine without proving the existence of a payable reef.

Near the surface loose lumps of rich stone were found, which were locally known as "spuds." These were evidently derived from the denudation of a rich vein in the vicinity, probably from the reef in the True Blue Mine. Seventy-three tons of these loose blocks were obtained, and yielded 128 oz. 8 dwts. of gold, or at the rate of 1 oz. 15 dwts. per ton.

Between the surface and the 170-foot level there are at least two reefs which are as much as two or three feet wide in places, but up to the present the stone in them has proved poor.

There has been raised from the reefs between the surface and the 100-foot level a total quantity of 347 tons, which yielded 159 oz., or 9 dwts. per ton, and 45 tons of second-grade stone, which gave on treatment less than 3 dwts. per ton. Mr. Channon has recently taken over the management of this mine; he proposes to experiment on the low-grade ore by dry crushing and cyaniding, and should this prove a failure further efforts are to be made to discover payable stone in the deep ground.

True Blue Mine.—This mine ranks next in importance to Neeld's and the Lucknow, at least on this line. The main Mallee Bull line of reef splits in this mine into two branches which diverge as they are followed southwards. The Junction is situated on the eastern one, and the Perseverance and Ledger Mines on the western one.

The two reefs have been opened up to a depth of 260 feet, and large quantities of stone have been stoped from them. They both dip to the east, the eastern one at a lower angle than the western; they are consequently becoming more separated as they are followed down. A winze was sunk on the eastern reef, 92 feet below the 260-foot level, and 30 tons of stone are said to have been raised from it which yielded 5 oz. per ton. Another winze was put down on the western reef from the same level, and to a depth of eighty-two feet. Nine tons from this winze are said to have yielded at the rate of 5 oz. 12 dwts. per ton, and 100 tons 17 dwts.; these parcels of stone came from a reef about 2 feet wide. I was unable to obtain the total returns from this mine.

Junction Mine.—This mine is situated on an extension of the eastern reef worked in the True Blue Mine. A vertical shaft cuts the reef at 315 feet from the surface. A large amount of rich stone has been raised from this mine, the full records of which I was unable to obtain. Three months previous to my visit 30 tons of rich pyritous stone were raised, of which 13 tons yielded 9 oz. per ton; 9 tons, 12½ oz. per ton; and 8 tons, 9½ oz. per ton. In addition to this 180 tons were treated at the batteries for a yield of 1 oz. 5 dwts. per ton. At the lowest level (350 feet) the rich ore seems to be extending into the adjoining claim, Maud's Jewel.

The mineralised reef in this mine varies from one to eighteen inches in width.

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Napoleon.—Several shafts were sunk on this ground, the deepest being 150 feet, but nothing more than a narrow belt of crushed country rock was met with, in which very small veins existed. One ton of stone picked out from these veins yielded 14 dwts.

No reef of any value has been obtained in the Mallee Cow or Empire Claims. A small vein was cut in the former, from which 7 tons of stone were said to have been taken, and to have yielded 5 oz. per ton. In the Empire Claim a band of crushed granite, four feet wide, was driven on for a distance of thirty feet, but very little quartz was met with.

Perseverance Mine.—This mine has yielded a considerable amount of rich stone, and is said to have paid about £8,000 in dividends.

Work was suspended in this and the adjoining mine, the Ledger, and I was consequently unable to examine the workings in either of them.

In the Perseverance Mine a vertical shaft cuts the reef at 230 feet, and from this point it has been followed down to 280 feet. About 1,000 tons of quartz are said to have been raised from this mine, and treated for an average yield of about 2 oz. per ton. The shoots of rich stone are said to have dipped to the south in this mine.

Maiee Gold-mine.—This is the most southern mine working on this line of reef. A shaft 270 feet in depth intersects the reef at a depth of 250 feet, which is very small. In the south drive at the 270-foot level the reef is not more than a few inches wide.

Seventeen tons of stone were raised from this mine and treated for a return of 8 oz., or at the rate of 9 dwts. per ton.

Perry's Line of Reef.

This occurs about twenty-five chains west of the Mallee Bull line; there are only a few mines on it, and, with the exception of Perry's claim, they have not been payable. Only one mine was working on this line at the time of my visit; this was the Ready Money, which includes Perry's claim. Gold was first discovered on this line at Perry's claim, and was later found at intervals along it for a distance of thirty-five chains. The general trend is N. 25° E. and S. 25° W., and the dip is easterly and about 70°.

In the Ready Money Mine the reef is very small, only two or three inches thick, and occurs in a band of crushed granite two feet wide.

A small reef was cut in the Grand National Mine at 220 feet, but the only stone raised from this reef was 5 tons from near the surface, which yielded 16 dwts. per ton. In the Great Britain Mine the reef has been sunk on to a depth of 310 feet; it is rather small, but has yielded some good stone.

Another short line of reef occurs to the south of Perry's line; on it are the Central (formerly known as Pooley's) and Nil Desperandum Mines.

The reef or reefs, for in the Central there are several small veins, are small, but some rich stone has been taken out of them between the surface and about 150 feet.

Another short line of reef occurs ten chains west of the above; this is the Mouse Trap. The whole line was practically idle. The payable stone seems to have been removed from the surface to the 200-foot level. The reef is very small, and only averaged from four to six inches. The trend is N. 20° E. and S. 20° W., and the dip is easterly. The returns from the Mouse Trap Mine are 240 tons, treated by battery, for 415 oz., or 1 oz. 14 dwts. per ton; and 147 tons, treated by chlorination, for 881 oz., or 6 oz. per ton.

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Currajong Line of Reef.

There are two reefs about 100 feet apart in the Currajong and Golden Fleece Mines, the two most important mines on this line. Their general strike is about N. 20° E. and S. 20° W., and the dip is easterly. The two reefs which occur in the Currajong Mine have not been traced with any degree of certainty north of that mine. It, however, seems probable that the main reef worked in the Hilderbrand, Yorkshire Lass, Two Up, and Dodger Claims is a continuation of the western reef of the Currajong Mine. To the south both reefs have been worked in the Golden Fleece and Keep-it-dark Mines.

Currajong Mine.—This is undoubtedly the most important mine on this line. There are two reefs—an eastern and a western one—both of which dip to the east. The main shaft, 310 feet in depth, is sunk between the two reefs, being eighty-seven feet east of the western reef at the surface, and twenty-seven feet east of it at the 310-foot level. The eastern reef is nearly vertical, being fifteen feet east of the shaft at the surface, twenty-two feet east of it at the 150-foot level, and twenty-five feet at the 230-foot level. (See Fig. 7.)

Currajong Mine.

Section across the reefs.

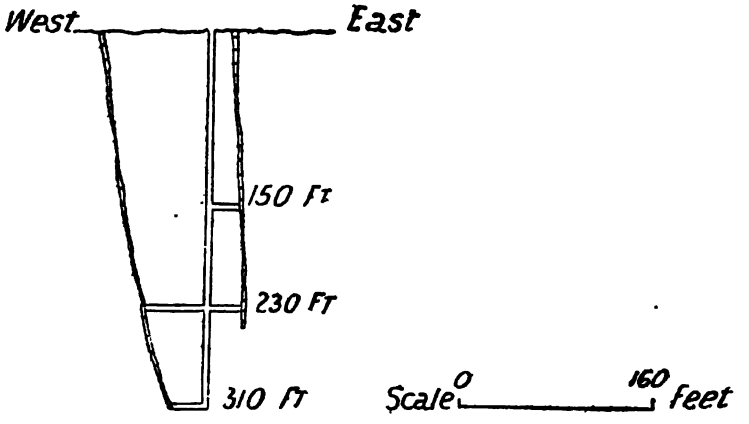

Fig. 7.

A large amount of stone has been raised from these two reefs. The western one is the richer of the two, and averages about nine inches in thickness.

This has been one of the most productive mines on the gold-field, and large dividends have been paid. I was unable to ascertain the amount paid previous to October, 1895, but since that date £13,700 has been received by the shareholders.

From August, 1897, to the present time, however, the proceeds from the mine have scarcely paid the wages of the miners employed. The mine is now being worked by two or three parties of tributors, who seem to be doing fairly well.

Hilderbrand's Mine.—This was a mine of some importance in the early days of the gold-field when rich stone was being raised from the soft ground.

There are at least three reefs, but they are all very small, and separated from one another by a few feet of granite. The stone has been stoped from this mine from the 150-foot level to the surface; from a vein three or four

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inches in thickness stone yielding 8 oz. to the ton was obtained. These small veins appear to extend northerly into the Yorkshire Lass, Two Up, and Dodger Claims, from all of which small quantities of payable stone have been raised.

Golden Fleece Mine.—This is south of the Currajong Mine, and in it the same two reefs occur that are found in the latter. Most attention has been paid to the western reef, which has been prospected to a depth of 320 feet.

Recently 107 tons were treated from this mine for a total yield of 67 oz., or at the rate of 12½ dwts. per ton but large quantities of stone have been raised from this mine of which I have no record.

Keep-it-dark Mine.—The Keep-it-dark Mine lies to the south-west of the above; in it are the same two reefs, with a third to the west of them. From this mine 643 tons of stone have been raised for a yield of 883 oz., or at the rate of 1 oz. 7½ dwts. per ton.

Other Lines of Reef.

Operator, Red Flag, and Wye's Mines.—In the extreme western portion of the gold-field there are several lines of reef, some of which have yielded large quantities of rich stone while they were worked in the soft ground. But as work was suspended in nearly all of them at the time of my visit I was unable to examine them, and therefore can give very little information about them. In the south-western portion there are at least three reefs to the west of the Currajong line. The following mines on these reefs have yielded rich stone in the soft ground, viz., Operator, Red Flag, and Wye's; but little or no work is now being done in them.

In the extreme north-western corner there are at least five more reefs in addition to those already mentioned. None of them are large, but they are rich in places, and have been profitably worked while the granite was soft.

White Reef and Welcome Stranger Mines.—The White Reef Mine has been a very productive one; but at the present time the reef is small and the ground is very hard. In the Welcome Stranger Mine there are two reefs, but only the western one has been worked, and that only to a depth of 150 feet, the extent of the soft ground. In the south end of this mine, near the 4Js' boundary, a show of rich stone 200 feet long was worked out to the surface; this seems to have dipped to the south. The average width of the reef was six inches. Between June, 1894, and December, 1896, 1,178 tons of stone were treated from this mine for a yield of 4,860 oz., or at the rate of 4 oz. 2 dwts. per ton. This mine has paid in dividends £2,000 per share, or £16,000 in all. No work has been done in the hard ground, and the mine is now idle.

Hidden Treasure Mine.—In the Hidden Treasure Mine three reefs have been found; two of these are identical with those which occur in the Welcome Stranger Mine, and the third appears to be that worked in the Three Star and Homeward Bound Mines. A vertical shaft has been sunk on one reef, and a second junctions with this at 140 feet, and at 200 feet another small vein joins it from the east. The mean width of the reef worked in the vertical shaft is about three inches, and the richest stone was taken from it between the 90- and 180-foot levels.

This mine was abandoned for about twelve months; but was taken up again in February of this year. Since that date 30 tons of ore have been treated for a return of over 53 oz., being at the rate of 1 oz. 15 dwts. per ton.

Gipsy Queen and Star of Peace Mines.—Good returns have been obtained from the Gipsy Queen and Star of Peace Mines, but I am unable to give the figures.

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Louisa Claim.—The Louisa Claim has yielded but a small quantity of stone; 57 tons are said to have been treated for a return of 78 oz. 7 dwts., or 1 oz. 7 dwts. per ton.

Homeward Bound Mine.—In the Homeward Bound Mine two reefs have been worked—one near the eastern boundary of the claim, and probably identical with the rich reef in the Welcome Stranger Mine, and the other is the same reef as that worked in the Three Star Mine.

Practically, all the work has been confined to the soft ground. On the first-mentioned reef two shafts, each 140 feet deep, and 150 feet apart, have been sunk, and connected by a drive; and a winze has been sunk to a depth of forty-seven feet below this level. At least 271 tons of stone have been raised from this reef and treated for a return of 453 oz. 3 dwts., or at the rate of 1 oz. 13 dwts. per ton; and 61½ tons from the other reef yielded 102 oz., or 1 oz. 13 dwts. per ton.

Three Star Mine.—In the Three Star Mine good stone yielding 1½ oz. per ton was found near the surface; but at 60-foot level the reef became much broken up, and at 160-foot level the reef averaged nine or ten inches in thickness, being as much as two feet in places, and 15 tons from it at that level yielded 1½ oz. per ton.

As the prospects seemed good a vertical shaft was put down; this, at 250 feet, was eighteen feet from the reef. At that depth the reef was found to be very small, from an inch or two to eight inches in width, and was firmly attached to the walls. Some driving was done on it at the lowest level; but as the prospects were not encouraging it was discontinued, and the mine has been lying idle for about twelve months. From this mine 327 tons were raised and treated for a yield of 348 oz., or 1 oz. 1 dwt. per ton.

Hill Top Mine.—The most western reef worked at Wyalong is that in the Hill Top Mine. It has been worked at intervals for a distance of 25 chains. In the Hill Top Mine it has been intersected by a crosscut 22 feet long from the bottom of a vertical shaft 230-foot deep. At this depth a drive 40 feet long was put in along the reef, which was found to be very small and of low value. About 300 tons of ore are said to have been raised from this mine from stopes between the 130-foot level and the surface. This stone averaged about 1 oz. per ton, but some of it yielded as much as 6 oz. 8 dwts. per ton. This mine is now idle.

Sunny Hill Extended Mine.—South of the Hill Top Mine, and on the same reef, is the Sunny Hill Extended, which includes what was formerly known as the Sunny Hill and Democrat Claims. From the north end of this mine about 300 tons of stone have been raised and treated for an average yield of 1 oz. 2 dwts. per ton. From the south end 150 tons of ore were raised, of which 18 tons yielded by chlorination 6 oz. 12 dwts. per ton, and the remainder was treated by the battery for a return of 9 dwts. per ton. This mine has not been worked for eighteen months.

Pioneer line of Reef.—The only other reef that it is necessary to describe is the one which forms the solitary exception in having an east and west trend. This is the Pioneer line of reef, on which the first discovery of gold was made.

The reef has been worked at intervals over a distance of twenty-five chains. It has a general strike of W. 10° N. and E. 10° S., and dips to the north. It has been worked in the following mines:—The Easter Gift (formerly known as the Dead Rabbit), Christmas Gift, Christmas Gift Block, Great Southern, and Pioneer.

Easter Gift and Xmas Gift Mines.—In the Easter Gift Mine the reef averaged about nine inches in width, but in the lowest level it was not more

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than three or four inches. About 114 tons of ore have been raised from this mine for a yield of 160 oz., being at the rate of 1 oz. 8 dwts. per ton. In the Xmas Gift Mine the shaft is 240 feet deep, and the stone has been stoped out in blocks from 140-foot level to the surface.

The shoots of rich stone seem to dip westwards. In this mine, at the 240-foot level, the reef is on an average nearly three feet wide, but it is too poor to pay for its removal.

5. *Genesis of the Deposits.*

As regards the origin of the ore channels, I have already expressed the opinion that they are due to the shearing of the granite along a number of approximately parallel lines, by which the zones of crushed granite or "formation" were produced, and spaces, more or less lenticular in form, which have become later occupied by the veins.

The minerals filling the spaces and forming the veins have evidently been deposited from solutions which have circulated through them. But there is practically no evidence to indicate the ultimate source of the minerals, or to show whether the solutions that deposited them derived their contents from the immediately adjacent portions of the granite, or brought them up from some deeper-seated source, probably in the granite itself. What little evidence there is is in favour of the latter view, for the ascending solutions appear to have penetrated laterally for a short distance into the granite walls of the veins, to have altered the granite, and in some cases to have deposited minerals in it.

PART IV.

The Metallurgical Treatment of the Ores.

At the commencement of mining operations at Wyalong all the stone raised from the mines was sent to Barmedman, a distance of eighteen miles, for treatment by battery; but when the value of the reefs was proved it was not long before batteries were erected at Wyalong. It was not until considerable quantities of stone had been treated by the ordinary battery that it was found that this method was totally unsuitable for the treatment of rich ores; for it was found that a large quantity was going away in the tailings.

The subsequent treatment of these tailings by the cyanide method has been the source of great profit to the owners of Duncan's and Channon's Cyanide Works, who are said to have purchased large quantities of tailings at a merely nominal price, which contained more than an ounce of gold to the ton.

When the great loss of gold arising from the treatment of the rich stone by battery was recognised, chlorination works were erected.

There are at the present time, at Wyalong, three batteries, one Huntington mill, two chlorination works, and two cyanide works. All of these works were kept fully occupied during my visit. All were not, however, treating highly payable ore, as a considerable amount of so-called "mullock" was being put through the batteries while the cyanide works were almost wholly devoted to the treatment of tailings, of which large quantities had accumulated.

Of the batteries Nicolas and Reymond's is the largest; it consists of 22-head of stampers, two Frazer pans, and two concentrators.

Gough's battery consists of 15-head of stampers and shaking bubles. Between 1st January and the 30th September of this year 2,977 tons of stone were treated at these works for a return of 1877 oz. 14 dwts., or 12½ dwts. per ton, and 518 tons of mullock for a yield of 98 oz., or 3 dwts. 19 grs. per ton.

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At West's battery, where there are 10-head of stampers, large quantities of "mullock" have been treated. This consists of low-grade material obtained from the dumps and from the old stopes in the mines. Material of this character naturally varies much in quality. From the beginning of the year up to the end of September 2,438 tons of this mullock were put through for a total yield of 371 oz. 18 dwts., or 3 dwts. per ton.

Mr. Cox has passed through his Huntington mill from the beginning of January to the 20th October of this year 1,688 tons of stone, which yielded 1,150 oz., or at the rate of 13½ dwts. per ton.

Wyalong Chlorination Works.—These were formerly known as Climo's works, as Mr. Climo was managing director at the time that they were erected; they are now owned by Mr. W. Sully.

They were started in 1895, but were not ready for the treatment of ore until the early part of 1897. They consist of a Krupp mill No. 6, a revolving roasting furnace, a cooling vat, 4 chlorination vats of a capacity of 24 tons each, and two cyanide vats of 45 tons capacity, also chlorine generators, &c. The present manager is Mr. Janitzky, and the accountant Mr. Shoobridge.

A very large amount of money has been spent on these works, but the results which have been obtained have not been altogether satisfactory. It seems doubtful whether the sulphide ores receive a sufficiently sweet roasting in the revolving furnace to enable a completely satisfactory extraction to be obtained. It has been found necessary in many cases to treat the material with cyanide solutions after their removal from the chlorine vats, in order to remove a further portion of their gold contents.

Stone, yielding from 1 oz. to 35 oz. per ton, has been treated at these works, in addition to 2,000 tons of tailings, varying in value from 5 to 25 dwts. per ton, and averaging ½ an ounce per ton.

At Neeld's chlorination works there is a Krupp mill with a reverberatory roasting furnace and nine chlorine vats. The capacity of this plant is about 40 tons per week.

Duncan's cyanide works have been established over two years. They are on the site formerly occupied by Gough's battery, where large quantities of rich ore were treated in the early days of the gold-field, with the production of rich tailings. These were acquired by Mr. Duncan, who has made large profits from the treatment of these tailings.

As the owner of this or other similar works do not give particulars of the amount and value of the tailings treated by them, no exact statement about these matters can be made. It is generally believed that a large part of these tailings have yielded more than an ounce of gold per ton. Concentrates ranging in value from 1 to 10 oz. per ton, and consisting largely of iron pyrites, have also been successfully treated at these works by the cyanide method.

A small plant was being erected at the time of my visit at these works to treat the raw pyritous ores by means of dry crushing and cyaniding.

I was informed that experiments had recently been conducted on the rich sulphide ores, with a view of ascertaining whether, by means of some modification of the cyanide process, these ores could not be more cheaply and advantageously treated by this method. I have been assured that on a small scale these experiments have yielded satisfactory results. Whether the gold is present in the free state or not in the sulphide ores is not known. If free, it must be in a very fine state of division, because gold is seldom visible in them. If it should prove possible to treat the sulphide ore successfully by the cyanide method, it will be a great boon to the field, as in nearly all

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the deep mines sulphide ores are making their appearance; and, as this method is a much cheaper one than chlorination, it means that ores which would not pay by the latter process would yield a profit by the former.

Some large parcels of rich sulphide ores, especially from the Lucknow Mine, have been smelted at Dapto, but the expenses are rather heavy, amounting to £3 15s. or £4 per ton.

Channon's Cyanide Works.—These works are on the site of an old roller battery, owned by Mr. Channon, which proved a failure.

There are three large leaching vats, of a capacity of 35 to 40 tons each. Zinc filings are used for precipitating the gold from the cyanide solutions.

About 10,000 tons of tailings have been treated at these works, from which £18,000 worth of gold has been obtained. The tailings have yielded, on an average, about 36s. per ton. There are still about 4,000 tons of tailings at the works, which it is expected will yield from 12 to 14 dwts. per ton.

The value of the tailings have decreased considerably of late, owing to the richer ore being treated by chlorination, and they do not now contain more than 6 to 8 dwts. per ton, while formerly large quantities contained as much as 2 oz. per ton.

The capacity of the works is about 150 tons per week.

PART V.

Other Auriferous Veins in the Vicinity of Wyalong.

All the reefs described in Part III occur within a tract of country about 120 chains square, and lie wholly within the area occupied by the granite.

Within the other geological area occupied partly by highly altered sedimentary rocks and partly by diorites passing into hornblende schist, auriferous reefs are not numerous, and only two have proved to be of any value within the area of the map accompanying this report. Of these, one is situated at Pine Ridge and the other on Pine Hill.

At Pine Ridge, which is situated about a mile and a half S. 20° E. of Wyalong Post Office, there is a band of altered sedimentary rocks, six chains in width, bounded on each side by diorite.

Close to the eastern side of this band is a quartz-reef, which dips to the east at an angle of about 80°. This reef has been worked for more than four years; but at the time of my visit only one claim was at work. I am unable to give the total yield from the Pine Ridge claims; but Mr. Leathley informed me that from his claim (M.T., 2) he had raised 101 tons of quartz, which yielded 111 oz. 11 dwts., or at the rate of 1 oz. 2 dwts. per ton. These figures do not include the contents of the blanketings and tailings, nor the return from the seventy tons of stone treated in the early days of the field, which was very unsatisfactory.

The reef averages about six inches in thickness; it widens out occasionally to about six feet, but where wide is usually of low value.

At Pine Hill, which is situated about one mile fifty chains S. 40° E. from Wyalong Post Office, there is a belt of sedimentary rocks about ten chains wide, bounded on each side by diorite. The reef there was not well defined; but rich patches of quartz, one yielding as high as 35 oz. to the ton, were obtained from it. I was unable to get the returns from the claims on this hill.

Called Back Reef.—This line of reef is situated within an extension of the Wyalong granite, and is distant about three miles N.N.E. of Wyalong Post

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Office. It was discovered nearly four years ago by Messrs. Hodge and Hunter, when on their return journey from the Nine-mile rush, and a short time after the discovery at Wyalong.

Gold-bearing quartz was found on the crown of the hill, near the southern end of the line. The strike of the main reef is N.E. and S.W., and its dip is slightly to the S.E.; but in places the reef is practically vertical.

A second reef lies about fifty feet to the east of the first; but little work has been done on it to prove whether it is of any value. The main reef has been traced for a distance of 1,200 feet, and at intervals along its course shafts have been put down on it, the deepest being 243 feet.

It is very remarkable that the country—rock, granite—is soft and decomposed even at that depth.

Water seems to be present in rather large quantity, and has retarded the development of this reef.

Some very good stone was taken from this reef in 1896, since when very little work has been done on it.

I am indebted to Mr. James Allen for the following information concerning the mines on the line of reef:—

Commencing on the north, the mines on this reef are the 9-acre Lease, Balaclava (G.L. 766), Lady Mary (formerly known as the North British Co. G.L. 769), Called Back United (G.L. 780), and No. 1 South. The reef has been worked principally in the Lady Mary and Called Back United Mines.

In the former the reef averages about two feet six inches in width, and the deepest shaft is 243 feet. About 160 tons of stone have been raised from the stopes between 125 and 170-foot levels, and have yielded 190 oz., or 1 oz. 4 dwts. per ton. The value of the stone ranged from 6 oz. to 6 dwts. per ton.

In the Called Back United Mine the reef varied in width from one inch to four feet, and averaged about two feet six inches. Fifty tons of stone, taken from some shallow shafts, yielded 10 dwt. per ton; and 215 tons from the stopes between 125 and 180-foot levels yielded 270 oz., or an average of 1 oz. 5 dwts. per ton.

From the Balaclava Mine only 48 tons of stone have been raised, yielding 50 oz., or 1 oz. 1 dwt. per ton.

No stone has yet been raised from the 9-acre Lease and No. 1 South.

Hiawatha.

While engaged on the geological examination of the Wyalong Gold-fields I paid several visits to Hiawatha, where prospecting operations were being vigorously carried on owing to the discovery of gold there in the early part of 1898. The site of the mining operations is about eight miles N.N.W. of Wyalong Township, on Portions 10 and 12, and the adjoining Crown lands of the Parish of Hiawatha, County Gipps.

Gold was first discovered on portion 12 by Messrs Conway and Ryan, and traced by them into the adjoining Crown lands. The discovery was made on Good Friday and reported on the following Monday.

All the reefs found at Hiawatha are in granite, which rock seems to occupy a large portion of the surrounding country, and would seem to be continuous with the Wyalong mass. All the reefs already found strike approximately E. and W., and dip to the north, and in these features differ from the Wyalong reefs, which have a general N. and S. trend.

The reefs are, on the whole, small and occasionally rich, but the gold contained in them is decidedly patchy in its distribution. In some cases, as at Molloy's Claim on Portion 10, rich prospects were obtained at the surface.

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The best yield obtained from any of the Hiawatha reefs came from Crawley and Party's Claim on portion 10, and was 38 oz. 13 dwts. of gold from 9 tons of stone, or at the rate of 4 oz. 6 dwts. per ton. From other reefs yields as low as 3 or 4 dwts. per ton have been obtained. On the Prospector's Claim on Crown lands, a shaft 87 feet in depth has been sunk, and some driving has been done on a band of crushed rock, in which are occasionally large masses of quartz. The returns from this mine have been 8 tons for 11 oz. 17 dwts., or nearly 1½ oz. per ton, 2 tons treated by chlorination for 2 oz. per ton, 6½ tons for 10 dwts. per ton, and 12 tons for 6½ dwts. per ton.

To the east of the Prospector's is Crampton's Claim (No. 1 East). The deepest shaft on this is 173 feet, vertical for 110 feet, and on the underlay for the remainder of the distance. The reef varies in size from 2 to 18 inches in thickness, averaging about 9 inches. The returns from this mine are 5 tons for 2 oz. per ton, and 16 tons for 5 dwts. per ton.

To the east of Crampton's Claim are two others known as "Early Morn," and "Nelson's." Ten tons of stone from the former yielded only 3 dwts. per ton, and 20 tons from the latter gave a similar yield.

Less than a quarter of a mile west of the Prospector's Claim, and on portion 12, is the "Blow." This is a large mass of quartz, which strikes east and west, and dips to the north. It has been sunk on to a depth of 60 feet and 10 tons from it are said to have yielded 9½ dwts. to the ton, and another 10 tons 8½ dwts. per ton.

On Portion 10 Mr. D. Molloy, who holds an area of 5 acres, is the original finder of the gold. The reef in this ground varies in thickness from an inch or less to twenty inches, and dips at an angle of about 60° to the north. In the west end of the drive, at the 55-foot level, is a large white reef of poor quality, and much stained by black oxide of manganese. A little galena and iron pyrites are present in the reef. The returns from this mine have been 9 tons for 1 oz. 14 dwts. per ton, and 43 tons for 18½ dwts. per ton.

The reef in the claim adjoining the above on the west is small, and no stone has been raised from it, but specimens showing gold freely have recently been found.

In the claim to the east of Molloy's much sinking and driving was done, but nothing of any value was found.

A quarter of a mile E.N.E. of Molloy's Claim is Crowley's Claim. There two reefs were found, one about seven inches in thickness, on the footwall, consisting of hard white quartz, and containing very little gold; the other, on the hanging wall, about six inches in thickness, consisting of sandy quartz, is fairly rich. The reefs strike E. and W., and dip at about 80° to the north. The returns from this claim are—10 tons for 1 oz. per ton, and 9 tons for 4 oz. 6 dwts. per ton.

The other claims in this neighbourhood are Wilcoxson's and Ryan's. From the former 10 tons have been raised, and treated for a return of 16 dwts. per ton. A peculiar feature of this reef is the occurrence in it of a pale green opal. From Ryan's Claim 8 tons were treated for a return of 4 dwts. per ton.

Two other claims were being worked at the time of my visit; these are situated west of Crowley's, and near the road. On Fletcher's a shaft has been sunk to a depth of 124 feet, and a crosscut 18 feet long intersected the reef, which is about eight inches thick.

Sixteen and a half tons have been treated for a yield of 1 oz. 3 dwts ton. No stone has been raised from Dawson's Claim, where a reef six wide occurs.

[Map.]

Sydney: William Applegate Gullick, Government Printer.—1899.

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NEW PLANT UNDER CONSTRUCTION.

EXISTING SMELTING PLANT.

H. Lowell Price.

General View of Great Cobar Copper Mine, showing New Plant under Construction.

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NEW SOUTH WALES.

DEPARTMENT OF MINES.

GEOLOGICAL SURVEY.

E. F. PITTMAN, A.R.S.M., Government Geologist.

MINERAL RESOURCES.

No. 6.

THE COPPER-MINING INDUSTRY

AND THE

Distribution of Copper Ores in New South Wales.

BY

J. E. CARNE, F.G.S.,

ASSISTANT GOVERNMENT GEOLOGIST.

SECOND EDITION.

1908.

SYDNEY: WILLIAM APPLEGATE GULLICK, GOVERNMENT PRINTER.

1908.

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TABLE OF CONTENTS.

	PAGE.
Introduction and Acknowledgment	1
Historical	6
Chronological Order of Opening of New South Wales Mines	10
Copper—probably the first Metal used by Man	12
Surface Indications of Copper Lodes	12
Natural Leaching of Copper Ores	13
Commercial Ores of Copper—their occurrence in New South Wales	17
Abandoned Mines and Re-opening	19
Development	21
Low-grade Deposits	24
Furnaces—	
Reverberatory Smelting ... / Cupola or Blast Smelting... / Pyritic Smelting	27
Treatment of Copper Ores, by W. H. Corbould	30
Smelting	33
Smelting Deductions	34
Great Cobar Electrolytic Plant, and Process of Refining, by G. H. Blakemore	36
Mineral Associates of Copper Ores injuriously affecting Smelting Operation or the quality of the Metal	41
Concentration	44
Concentration and Smelting Plants at the Washoe Plant, Anaconda, U.S., by L. S. Austin	48
Permanence of Copper Lodes	57
Depths of American Mines	59
Copper Mines of the World, by W. H. Weed	59
The Mineral Industry during 1906, by W. R. Ingalls	60
Depths of New South Wales Mines	61
Bedded Deposits	61
Brief Descriptive Notes of famous Copper Mines (for comparison)—	
In South Australia (Moonta, Wallaroo, and Burra Burra)	63
In Queensland (Peak Downs, Chillagoe, and Mount Morgan)	66
In Tasmania (Mount Lyell)	70
In Germany (Mansfeld)	74
In Spain (Rio Tinto and Tharsis)	75
Wet Methods of Extracting Copper at Rio Tinto, Spain, by C. H. Jones	75
In United States (Lake Superior and Montana)	79
Copper Mines of Japan, by W. H. Weed	84
Statistical Return of Copper Output of—	
Australasia	86
The World	88
Descriptive Register of New South Wales Copper Mines and Occurrences	90

193012

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PAGE

Refractory Materials locally used in the Manufacture of Fire-bricks, with Analyses of other Fire-clays of New South Wales suitable for Fire-bricks, &c. 399

Limestone 405

Appendix I—Local Customs Smelting Works, and their Tariffs 407

Appendix II—Additional Notes on Ettrema and Talwong Mines..... 413

Appendix III—Methods of Acquiring Titles to Prospect or Mine for Copper on Crown Lands 415

Map of New South Wales, showing Mining Districts and Divisions to illustrate the Distribution of Copper Ores ..... End of volume.

Digitized by Google

LIST OF PLATES.

	PAGE.
Great Cobar Copper mine—General View	Frontispiece
Broken Hill—Outcrop of Lode	16
Great Cobar, Limited, Roasting and Electrolytic Plant, Lithgow	34
,, ,, Depositing Tanks	38
Mt. Morgan, Open Cut	66
,, Steam Shovel	67
,, Blast Furnaces	68
,, Converters	69
Table showing Australian Copper Production	87
Comparative Table, Production and Consumption of Copper, 1906	88
Blayney Copper Mines—Works	111
,, ,, Winch converted into Shell of Copper	113
,, ,, Converter Plant	114
Lloyd Copper Mine—General View	117
,, ,, Section	120
,, ,, Plan of Workings	121
,, ,, Concentrating Mill	122
,, ,, Roasters	123
,, ,, Smelting Works	124
,, ,, Refining Plant	125
,, ,, Reservoir	126
Cadia Copper Mine	127
,, ,, Iron Duke Outcrop	128
,, ,, Smelting Works	132
,, ,, Iron Duke Workings	132
Cangai Copper Lode	181
,, Smelting Works	182
,, Plan and Section	186
Cobar Chesney Main Shaft	198
,, ,, Mine Section	199
Crowl Creek, Shuttleton, Plan and Sections	212
Girilambone Copper Mine	218
,, Main Drive	220
,, Refinery	223
Great Cobar Company Main Stack	228
,, ,, 90-fathom Level	233
,, ,, ,,	240
,, ,, Interior of Smelter Building	242
,, ,, No. 1 Blast Furnace	243
,, ,, Nos. 1 and 2 Converter Vessels	244
Mt. Hope Copper Mine	250

Digitized by Google

PAGE.

Mt. Hope Copper Mine Smelting Works 252
Nymagee Copper Mine 255
,, ,, Plan and Section 258
Belara Copper Mine 286
,, ,, Plan 287
Mount Stewart Mine, Leadville, Plan 296
Gulf Creek Copper Mine 322
,, ,, Smelting Works 324
Frogmore Copper Mine 346
Lake George Copper Mines 355
Talwong Copper Mine 366
,, ,, Shoalhaven River Gorge 367
Lobb's Hole Copper Mine, Yarrangobilly 384
,, ,, ,, Plan 386
Snowball Copper Mine, Plan 392
English and Australian Copper Smelting Works, Waratah 409

AT END OF VOLUME.

Lloyd Copper Mine—Plan of Reverberatory Furnace.
,, ,, Plan of W. Thomas' Hearth Reverberatory Furnace.
Great Cobar, Limited—Details of Construction of Electrolytic Copper-refining Plant.
Map of New South Wales, showing Mining Districts and Divisions and principal Copper Lodes.

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LETTER OF TRANSMITTAL.

Department of Mines,
12th August, 1908.

Sir,

Mr. J. E. Carne's Monograph on "The Copper Mining Industry, published in 1899, proved so useful to the mining community that there has been a continuous demand for it, and in view of the marked advance which took place in copper production in 1907, consequent upon the increased price of the metal, it was felt that a second edition was almost a necessity. This has now been prepared by Mr. Carne, and it will be found to contain a large amount of new and valuable information, which will doubtless be appreciated by mining men. The book is practically a record of the work done upon copper deposits in this State, and, as such, it must always be of use to persons contemplating the reopening of old mines, when improved conditions in regard to price of metals, methods of treatment, &c., appear to give promise of success.

I think that Mr. Carne is to be congratulated upon the manner in which he has completed his work.

I have the honor to be,
Sir,
Your obedient servant,
E. F. PITTMAN,
Government Geologist.

The Hon. W. H. Wood, Esq.,
Minister for Mines.

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The Copper-mining Industry and the Distribution of Copper Ores in New South Wales.

Introduction and Acknowledgment.

The copper-mining industry of New South Wales, after languishing for several years owing to the low price of copper and the consequent closing of some of the principal mines, entered upon a new era of prosperity about 1894, when the Great Cobar Mine was reopened under the advantages of improved and accelerated methods of ore reduction, and of rapid and constant transport afforded by railway communication with the sea-board.

The success of the undertaking was, moreover, influenced to no small extent by realisation of the intrinsic worth of the valuable associated metals previously ignored, and augmented and confirmed by the steadily increasing value of copper—from £39 in 1893 to £75 in February, 1899.

This substantial advance stimulated interest in copper properties both old and new, and awakened a desire to look further into mines long since closed under less favourable conditions. The interest awakened, however, was slight compared with that following the phenomenal rise to over £100 per ton in 1907. Many of the early mines were reopened to ascertain whether under advanced metallurgical methods and reduced costs they could be profitably worked. Such early mines as Currowong, Snowball, Frogmore, Ophir, Belmore, Britannia, Copper Hill, Apsley, Wertago, Green Swamp, Cadia, and Goodrich being among the number. Unfortunately for the majority, the boom was too brief; by the time the old workings were unwatered and secured, the fall had begun and capital was scared.

The time being opportune, an attempt is herein made to supply useful information for the benefit alike of the prospector, miner, and investor, by collecting and bringing up to date all the available information the Writer has been able to glean concerning the inception and progress of the copper-mining industry, and of the distribution of copper ores in New South Wales. Its object is threefold—concentrating the substance of early references and reports, recording present conditions, and registering known copper occurrences and localities. To this end public and private documents have been carefully noted, whilst the experience of many prominently connected with the industry, and the personal knowledge of the Writer and his colleagues of the Department of Mines, have been placed under tribute.

It is believed that a useful purpose is served in thus presenting in convenient form the sum-total of our knowledge of the subject, and in con-

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centrating information previously scattered through numerous documents and publications, the earlier portions of which at least are hardly available to the general public.

Each of the States of Australasia has become noted for abundance of one or more essential elements of mineral wealth and prosperity; thus New South Wales for coal, silver, tin, and lead; Victoria, New Zealand, Queensland, and now the youngest State—West Australia—for gold; South Australia for copper; and Tasmania for tin and copper.

In copper New South Wales ranks second to South Australia as regards the total value of production to date, whilst Queensland, thanks to Mount Morgan, assumed the premier position in the annual output in 1906, Tasmania, which held that position from 1897, taking second place, New South Wales third, and South Australia fourth. The relative figures for each of the States are as follows :—

State.	Total Production to end of 1906.*	Production for 1907.	Total Production to end of 1907.
	£	£	£
South Australia	25,575,846	691,888	26,267,734
New South Wales	8,472,629	727,774	9,200,403
Tasmania	6,753,561	869,666	7,623,227
Queensland	4,402,003	1,028,179	5,430,182
Western Australia	478,129	180,387	658,516
Victoria	123,454	2,356	125,810
Total	45,805,622	3,500,250	49,305,872

* Supplied by Commonwealth Statistician.

In bringing the chequered history of the local copper-mining industry up to date, advantage has been taken of the opportunities afforded by consideration of individual enterprises, to contrast past and present difficulties besetting them, and the methods and processes experience and altering conditions have suggested and enforced.

Copper mining, no less than that of the nobler metals, has had its "boom" times and its reactionary depressions, the causes of which in some instances were not far to seek—notably the fictitious advance in value in 1888 consequent on the futile attempt of a French Société des Metaux to "corner" the market, which entailed loss and disappointment through speculative investment and attempted exploitation of unworkable deposits. Slowly, but surely, the industry recovered from the inevitable fall in values following the Society's failure. The steadily-maintained advance in the market value of copper, notwithstanding the rather disconcerting jump to £75 per ton in February, 1899, attributed to a similar attempt to control the market, continued as the natural outcome of increased and healthy demand, culminating in 1900 in an average of £73 2s. 5d. and £78 9s. 1d. for "standard" and "best selected" copper. "Towards the end of 1901 the reaction in European trade became very pronounced."[1] As a result of reduced consumption, aggravated by heavy stock-selling, the average prices for the above grades fell to £52 8s. 3d. and £56 12s. 7d. in 1902, rising again in June, 1907, to £103 4s. 4d. and £111 8s. 4d. (according to the Commonwealth Statistician), when a fluctuating fall began, until £62 10s. was reached in October and December.

[1] A Century of Copper, 2nd ed., 1906, p. 17.

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The following interesting table of fluctuations in the value of copper from 1896 to June, 1907, has been prepared by Mr. G. H. Knibbs, Commonwealth Statistician,[1] who also kindly supplied the earlier returns from 1893 from the files of the *Economist*:—

Year.	Average Price of Copper per Ton.		
	Standard.	Best selected.	
	£ s. d.	£ s. d.	
1893	42 16 5	48 0 0	
1894	40 13 8	43 7 6	
1895	42 18 2	46 18 4	
1896	46 18 2	50 13 5	
1897	49 2 6	52 5 6	
1898	51 16 7	55 8 3	
1899	73 13 9	78 2 3	
1900	73 2 5	78 9 1	
1901	66 19 1	73 8 2	
1902	52 8 3	56 12 7	
1903	58 3 2	62 13 1	
1904	59 0 7	62 13 0	
1905	67 2 1	71 3 9	January to June.
1905	72 1 11	77 7 11	July to December.
1906	82 2 8	86 18 11	January to June.
1906	92 15 1	97 11 1	July to December.
1907	103 4 4	111 8 4	January to June.

Comparative Statement of Yearly Average Prices compiled by the Metallgesellschaft and the Metallurgische Gesellschaft A-G. (14th Ann. Issue 1898 1907, March, 1908, p. 5 :—

	Standard (London).	Best Selected (London).	Lake (New York).	Electrolytic (New York)
	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1906	87 8 6	92 5 0	90 10 0	88 18 1
	87 1 8	93 14 6	95 5 0	92 5 2

The following notes from Aron Hirsch and Son's "Copper Outlook," to the end of February, 1907, are of special interest in view of the recent phenomenal rise and subsequent recession of values :—

Page 6. "In recent issues we have been able to describe the period under review as a record year of the copper-mining industry; 1906 may more aptly be described as a record year of *consumption*. Mining industry received its greatest impetus from higher values ruling in 1904 and 1905 (£60-£70). Increase of production in 1906, proportionately appreciably smaller, notwithstanding higher values, £90-£100."

Page 7. "Germany, France, United Kingdom, and United States consume about 80-90 per cent. of the world's production. Of the total consumption of these countries—670,543 tons—the United States consumed 316,964 tons."

Page 6. "Whilst in 1891, with a world's production of 279,309 tons, the North American countries (in which class we include Mexico and Canada, the product of these being for the most part refined in North America) produced 136,874 tons—less than half the total production—in 1906 North America's share formed 70 per cent. of the entire world's production."

[1] Official Year-book of the Commonwealth of Australia, No. 1, 1908, p. 412.

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Pages 10 and 11. "In conclusion, we repeat that in 1906 the world's consumption of copper exceeded its production by 51,297 tons (in the years 1902, 1903, 1904, and 1905 consumption was respectively 51,799, 26,899, 32,856, and 54,772 tons greater than the production). It is quite impossible to state in figures what portion of these 51,297 tons should be considered as an actual deficit. A most important point is that the invisible, or rather indeterminable, stocks in the hands of manufacturers are reduced to the very utmost possible level, or we may rather say they are nearly exhausted. As a large part of the production until well into the summer of this year (1907) has already been sold to consumers, and the latter, in spite of this, are still insufficiently covered with supplies, the situation is most serious, the more so because there is lack of any stocks, apart from the small stocks of standard copper in England—5,600 tons at the end of February, 1907. One can therefore understand the considerable advance in price, and it is clear that this advance has not been artificial. But such conditions are not healthy in the interests of the industry, and it is much to be hoped that the tension, and with it the exceptionally high prices, may give way somewhat. For this, an increase in production would primarily be needed; but there are as yet no indications of any appreciable increase. The price of copper will much depend upon the development of economic conditions in general. The whole world, but Germany and the United States in particular, now enjoys an industrial prosperity which has never been equalled. The world's demand for raw and industrial products of every description is phenomenal. But this state necessitates supplies of money in such abundance that one is not certain whether the scarcity of money does not actually signify that the boundaries of present conditions have been reached."

In view of subsequent financial troubles in the countries specifically mentioned, the concluding part of the latter paragraph was prophetic.

As all authorities are agreed upon the excess of consumption over production during the period mentioned, it seems tolerably certain that the fall in values during the latter part of 1907 (which continues) was due to lessened consumption, and not to market manipulation principally.

The magnitude of the United States consumption (47·2 per cent. of the world's consumption in 1906—Hirsch and Son) and its influence on the copper market is forcibly realised when financial panic and industrial stagnation temporarily supervene in that country.

"Booms" are unhealthy stimulants of mining industry. Financial exhaustion and distrust inevitably follow feverish speculative excitement and over-confidence.

Abnormal increases of metal values likewise dislocate trade and create fictitious market standards, from which even moderate recession is regarded as depression, notwithstanding superior averages maintained over preceding years.

Established mines benefit during the period of inflation, but those inaugurated because of it suffer proportionately to failure of the high margins on which they were floated.

"Booms," moreover, stimulate injudicious enterprises which would be impossible under normal conditions. Unscrupulous market manipulation is an inevitable consequence of a "boom." On the strength of legitimate discovery "wild cat" offshoots are sprung on the public, usually under misleading nomenclature, implying lode connection.

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Frequently, without the slightest stratigraphic evidence of extension or parallelism, the familiar "Norths," "Souths," Easts," or Wests," and their inevitable "Extendeds," "Blocks," and "Underlays," are set as traps for the public, baited with the magic names of successful or promising mines, and not always with too slavish regard for the implied connection.

Doubtless the spirit of gambling underlies a good deal of "wild cat" speculation. Hope of sudden enrichment—beyond the scope of prosaic business—lures ordinarily shrewd men to reckless mining investment. Rumoured discovery, whispered secrecy—another Mount Morgan! a second Broken Hill! or a mysterious "Big Hole" with gold and diamonds!—secure victims as gullible as those who trust the disinterestedness of the casual acquaintance with the rich uncle in Fiji.

Alluring hope of unearned increment, large and immediate, claims its dupes in professional and business ranks as easily as in bucolic. Native caution, professional and business instinct, yield before the mining syren.

From the wiles of smaller fry—the "Monte man" and "thimble-rigger"—beneficent legislation protects the unwary or vicious. From "mining shark" and "market rigger" is there no protection? The former victimises in shillings; the latter in fortunes. The former is anathema; the latter tolerated, if not envied.

Discovery is the harvest time of the illegitimate mine (?) floater and boomer, who garners his gains before independent report protects and guides investment. The longer the delay in reporting, the greater the harvest gleaned. Instant publication of facts of occurrence, and proving, without comment, protects public interests, without "booming" legitimate enterprise.

Each important productive deposit has herein received independent historic notice, embracing all available particulars of discovery, size, nature of the ores, extent of development and output,[1] and the methods of treatment adopted. In each case where the mine is still working, these data have been brought up to the present chiefly from personal inspection by the Writer. The individual descriptions may in some instances appear prolix; but experience has proved that even apparently trivial details have a value, and are eagerly sought by those desirous of information on which to base a decision.

In noting the occurrence of copper, no restriction has been adopted in the register; but with a desire of imparting knowledge of the distribution of the ores of this metal throughout the State, its scope has been widened to embrace all cupriferous localities irrespective of abundance or richness. The individual references, however, contain all that is known of each deposit.

The presence of copper in a locality may be a guide to prospectors, and a record of proved unworkable deposits may prevent useless expenditure or misrepresentation.

Brief descriptive notices of some of the principal copper lodes of the world, and the metallurgical and other processes connected therewith, have also been introduced for comparison and instruction.

Here the Writer desires to acknowledge the obligation he is under to Mr. W. H. Corbould, Managing Director of the Lloyd and other copper mines, who, with a view to assisting in the early issue of this work, generously volunteered to extract items of interest from recent literature on the subject, and in other ways rendered valuable aid.

[1] In some instances the outputs may be only approximate as they are dependent entirely upon the courtesy or willingness of the owners, returns not being compulsory under the New South Wales Mining Act.

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To the useful Office Register ot mineral localities compiled by Mr. O. Trickett, L.S., Draftsman to the Geological Survey, the Writer is indebted for his initial list, and for preparation of plans and sections for printing.

To Mr. Leonard Dodds and Mr. S. L. Bensusan special thanks are due for assistance most generously given in connection with the first edition of this work.

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To the splendid works on Modern Copper Smelting and the Principles of Copper Smelting, by Dr. E. D. Peters, junior, the Writer is indebted for much valuable information, which has been freely used in this work.

Likewise to the useful statistical review, "A Century of Copper," by N. Brown and C. C. Turnbull.

To Mr. W. S. Dun, Palæontologist and Librarian, for assistance in proof reading, indexing, and revision; to Mr. G. W. Card, A.R.S.M., Curator and Mineralogist, for determination of numerous rock sections; to Mr. J. C. H. Mingaye, F.I.C., F.C.S., Analyst and Assayer, and his Laboratory Staff, for the very numerous assays and analyses herein recorded—the Writer tenders appreciative acknowledgment.

Historical.

The first notice of the occurrence of copper ores in Australia is probably that recorded by G. Caley, Botanist, in a letter to Sir Joseph Banks, dated 12th October, 1800: "Iron abounds here in great abundance. I have lately received a small specimen of stone which contains copper. [Possibly from Narrabeen.—J.E.C.] I have been told by a Cornish miner that he has met with tin." (Historical Records, New South Wales, 1800-1802, p. 239.)

Surgeon Cunningham mentioned: "Have seen copper ore from Bathurst" (probably in 1825 or 1826). (Two Years in New South Wales, 1827, vol. II, p. 11.)

Copper-mining probably began in New South Wales between 1844 and 1845. In the latter year, Mr. James Ranken, of Bathurst, visited mines at work at Copper Hill, near Molong, and at Lipscombe Pools Creek, 14 miles from Canowindra; the late Mr. W. M. Rothery, on whose station the latter is situated, confirmed this date, and afforded particulars of the work performed. In 1847 Mr. Ranken also visited the operations in progress on the Summerhill Estate, near Rockley. In 1848 the prospectus

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of a proposed company to work the lode at the latter was published in the *Bathurst Advocate* of the 30th December of that year. Probably this is the earliest public announcement of a local copper-mining enterprise, if, indeed, it be not the earliest metalliferous mining company formed in the State, for it is more than probable that copper was the first metal mined in New South Wales.

The object of the Bathurst Copper-mining Company was set forth in the prospectus quoted:—"Copper ore having been discovered on the estate of John Findlater Clements, Esq., known as Summerhill, situated on Campbell's River, about 25 miles from Bathurst, thirty individuals agreed to subscribe £30 each, and formed themselves into an association for the purpose of opening a mine on that estate, with the ultimate view of establishing a public company, should their operations turn out favourably in the meanwhile."

After sinking a shaft and other prospecting, the report of an experienced miner, Mr. John Whitford, was obtained, to the effect that a lode had been disclosed which, in his opinion, could be worked with considerable profit. The right of mining over the estate of 1,500 acres was secured for twenty-one years, with the option of renewal for a like period.

Materials requisite for erecting smelting works were reported to occur on the ground.

In 1853 a Select Committee of the Legislative Council reported on a Bill to incorporate the company, whose object was then widened to "open and carry on mines and mining operations at Summerhill, and to obtain copper and other ores, and to dispose of same, and to smelt and refine all or any of the said ores on the land opened or elsewhere."

The first copper and lead ores mined in Australasia (in South Australia and New Zealand) were shipped to England for treatment. As early as 1846 the *Mining Journal*[1] advocated the wiser plan of utilising the coal resources of Newcastle in reducing the metals from their ores, instead of shipping the latter abroad, a course which was shortly adopted, for in the same journal[2] mention is made of the production of the first refined copper at the "Newcastle Copper-smelting Works" in this State (from South Australian ores). Though mines were at work in New South Wales, and it is believed that two or more smelting works were connected therewith, there is no official record of export at the Customs Office prior to 1858, when 58 tons were entered.

The earliest official record of copper-mining is that contained in a despatch from Governor Sir Charles Fitzroy to the Right Honorable Earl Grey, dated 1st March, 1849,[3] which as an epitome of the mining of that date is worthy of insertion *in extenso*. In it the Governor urged the expediency of a geological and mineralogical survey of the Colony, as the subject had been engaging attention for several years in consequence of the great success attending the opening of some of the copper mines of South Australia, in which Colony the first copper lode had been discovered and opened in 1842. He further added that—

"Copper mines are already in operation in the neighbourhood of Yass [Good Hope?—J.E.C.] and at Molong [Copper Hill.—J.E.C.], near Wellington Valley.

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[1] Vol. XVI, p. 486. [2] Vol. XXII, p. 66, 1852.
[3] Votes and Proceedings, Legislative Council, 1849.

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"The success which has attended the opening of these mines has as yet only been partial; but experiment has not yet proceeded far enough to test with any certainty their ultimate productiveness. It is also contemplated, I understand, to open mines in the neighbourhood of Carcoar [Coombing?—J.E.C.], in the county of Bathurst, and at Summerhill, in the same county, where strong indications of the existence of lodes of sufficient richness to justify their being worked have for some time been known to exist.

"A lead mine was opened during last year in the neighbourhood of Yass [Woolgarlo?—J.E.C.], but has been abandoned in consequence of its not being proved sufficiently productive to defray expenses of working it.

"An iron mine was also recently opened in the neighbourhood of Berrima [the Fitzroy Mine, Nattai.—J.E.C.]. It may not be superfluous to add that all the mines which have as yet been opened are on lands which have been alienated from the Crown without any reservation of the mineral rights."

The Governor concluded by recommending that a competent geologist be sent out. The position was subsequently offered to Mr. Beete Jukes, who declined it. Afterwards Mr. Bristowe was selected, but did not take up the work for family reasons. Later, Mr. S. Stutchbury was appointed to the position of the first Government Geological Surveyor, which he occupied until 1855, when he resigned on account of failing health.

In 1803, Mr. A. W. H. Humphrey was appointed as Mineralogist to the Territories of New South Wales. His arrival in March was noted; but there is no record of any reports having been furnished by him.[1]

In 1851, Mr. J. R. Hardy, Commissioner for Crown Lands for the gold district, writing to the Governor, on 12th June, from Summerhill Creek, near Orange, reported that several Cornish miners had applied to him to be allowed to work copper ore on the same terms as gold, namely, on payment of 30s. per man monthly.[2] Mr. Hardy recommended that the request be granted if within the province of the Government, as it was very desirable that every valuable article of export should be developed, and that it would give back loading to teams bringing supplies to the gold-fields, thereby lessening cost of transit.

On the 24th June the Governor invited the attention of the Executive Council to the application. The latter, however, was of opinion that "there was no such analogy between digging for gold and working copper mines as to render practicable the application of the same code of regulations to both." It, however, recommended "that until proper regulations were established for the working of metals other than gold, that any Crown lands containing such should be surveyed and offered for sale as mineral lands at an upset price sufficient to cover their proper value."

The difficulty of ascertaining the latter doubtless caused the abandonment of this idea of dealing with metalliferous lands, for no provision was made in the first Mining Act, issued in 1852, which was confined to gold-mining only. Nor did that of 1855, which repealed the previous Act and substituted the "miner's right" for the license to mine, and also provided for the issue of gold-mining and business leases, make any provision for minerals other than gold. Neither did the Act of 1857 remedy this defect.

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[1] Lord Hobart to Governor King, 24th February, 1803, Hist. Records N. S. Wales, 1803–1806, p. 47.

[2] Probably at Carangara, near Byng, afterwards known as the Cornish Settlement.

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In the Crown Lands Act of 1861 provision was first made for mineral leases; prior to this it would appear that copper-mining was entirely confined to private lands or was unprotected by specific title.

The first copper lease registered in the Departmental records, so far as can be ascertained, was in 1864, being portion 448, parish Baring, county Westmoreland, taken up by H. Donnelly.

In 1851 the first geological examination of the then known copper lodes of the Colony was begun, for in the official records of that year are embodied reports by Mr. S. Stutchbury, Government Geological Surveyor, and the Rev. W. B. Clarke, who was also engaged by the Executive Council to make geological examinations, chiefly, however, in connection with gold; but, as was characteristic with Mr. Clarke's work, little escaped his keen observation, hence references to copper localities are frequent in his reports.

Apparently Mr. Stutchbury's first duty on arrival in the State was the systematic examination of the copper mines in operation, and of all known cupriferous localities. Under the names of the mines in the descriptive record of this paper will be found details of his report on them at that early date. In these introductory notes brief references will be given.

It is significant that as early as the 12th April, 1851, inspired doubtless by phenomena observed in his travels, he took the opportunity of chronicling his opinion "that the large masses of iron ore found in veins and on mountain tops will, in some way or other, be found to be connected with copper or other metallic lodes." Probably the allusion was to gossany outcrops destitute of any surface traces of copper ores which might naturally be expected to mark the decomposition of cupriferous pyrites. In another portion of this work this interesting subject will receive further attention.

In 1851 Mr. Stutchbury reported on the Summerhill, Coombing, Cornish Settlement (Carangara), and other mines, and on deposits then unopened.[1]

In the same year Mr. (afterwards Sir Thomas) Mitchell, Surveyor-General, in a report on the gold-fields of the Bathurst District, mentioned copper mines at Kyong (probably Guyong, near Carangara) and at Copper Hill, near Molong, but gave no particulars.

In September, 1851, the Rev. W. B. Clarke recorded the presence of copper ores in "more or less abundance" a few miles to the westward of Inverary Quarry, in the Marulan District; also their occurrence in the neighbourhood of Boro, where the Mulloon Copper Mine was afterwards opened, about 1872.

In February, 1852, he noted the presence of copper and lead ores at Quidong, near the Snowy River, close to the Victorian border, and anticipated a profitable mining field. In 1868 the prospectus of the "Belmore Freehold Silver and Lead Mining Company," Quidong, was announced in the Press. Subsequently, prospecting operations were begun both for the silver-lead and the copper ores, and a furnace and battery erected; but apparently little ore was obtained, as the furnace betrays slight evidence of use.

[1] Mr. Stutchbury's reports are published in Votes and Proceedings of the Legislative Council under the years mentioned, and may be seen at the Public Library.

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The approximate chronological order of opening of the best-known copper mines in the State is as follows:—

Year.	Mine.	Mining District.	Division.
†1845 ...	Copper Hill	Bathurst	Molong.
1845 ...	Little Copper Hill	,,	,,
1845 ...	Belubula	,,	Canowindra.
†1846 ...	Summerhill	,,	Rockley.
1847 ...	,,	,,	,,
1848 ...	Good Hope	Southern	Yass.
†1849 ...	,,	,,	,,
†1850 ...	Coombing Park	Bathurst	Carcoar.
†1850 ...	Carangera	,,	Orange.
†	Cadia	,,	,,
	Cadia Extended	,,	,,
†	Icely	,,	,,
†1851	Ophir (1852)	,,	,,
to	Britannia	,,	,,
1865	Belmore	,,	,,
	Moonta	,,	,,
	Nelson	,,	,,
	Geurophian	,,	,,
†1872 ...	Essington	Bathurst	Rockley.
†1874 ...	Frogmore	Southern	Frogmore.
†1874 ...	Pride of Frogmore	Southern	Frogmore.
1874 ...	Lobb's Hole	Tumut and Adelong	Kiandra.
†1874 ...	Snowball	,,	Gundagai.
†1874 ...	Belara	Mudgee	Wellington.
†1875 ...	Apsley	Bathurst	Bathurst.
†1875 ...	Belmore	,,	,,
1875 ...	Glamorgan	Clarence and Richmond	Copmanhurst.
1875 ...	Bobby Whitlow	Peel and Uralla	Bingara.
†1876 ...	Burraga	Bathurst	Burraga.
†1876 ...	Wertago	Albert	White Cliffs.
1877 ...	Burley Jacky	Bathurst	Cowra.
1877 ...	Esmeralda	,,	Bathurst.
†1877 ...	Bundarra	Peel and Uralla	Bundarra.
†1878 ...	Mount Hope	Cobar	Mount Hope.
†1878 ...	Great Central	,,	,,
1878 ...	Cyclops	Tambaroora and Turon	Stuart Town.
1878 ...	Mount Ragan	Bathurst	Orange.
1878 ...	Green Swamp	,,	Bathurst.
†1879 ...	Nymagee	Cobar	Nymagee.
†1880 ...	Girilambone	,,	Nyngan.
†1881 ...	Blayney	Bathurst	Blayney.
†1881 ...	Eurow and Vychan	Lachlan	Forbes (?)
†1881 ...	Trough Gully	Peel and Uralla	Nundle.
†1882 ...	Lake George (Captain's Flat)	Southern	Bungendore (?)
1882 ...	Pluck	Clarence and Richmond	Copmanhurst.
†1886 ...	Mount Beppy Copper	Cobar	Canbelego.
1887 ...	Mount Jasper	Hunter and Macleay	Port Macquarie.
1888 ...	Sydney-Wallaroo	Mudgee	Dandaloo.
1890 ...	Mount Lant	,,	Denison Town.
1891 ...	Willi Willi	Hunter and Macleay	Kempsey.
†1894 ...	Mount Everest	Peel and Uralla	Bingara.
†1895 ...	Gulf Creek	,,	Barraba.
1895 ...	Mayfield	Southern	Burrowa.
†1895 ...	Mountain Run	Bathurst	Rockley.
†1895 ...	Phœnix	,,	Oberon (?)
1897 ...	Tuglow	,,	Oberon.
1897 ...	Christmas Gift	Mudgee	Dandaloo.
1898 ...	Elizabeth	,,	,,

† Furnaces established in connection therewith.

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Year.	Mine.	Mining District.	Division.
1898 ...	Mount Pleasant	Mudgee	Dandaloo.
1898 ...	Bob's Mount	Bathurst	Orange.
1898 ...	Monaro	Tumut and Adelong	Cooma.
1899 ...	Kangiara	Southern	Yass.
†1899 ...	Sugarloaf	Bathurst	Rockley.
†1900 ...	Crowl Creek	Cobar	Nymagee.
1900 ...	Lobb's Hole Central	Tumut and Adelong	Kiandra.
†1901 ...	Cangai	Clarence and Richmond	Copmanhurst.
1901 ...	King of England	Lachlan	Cowra.
1901 ...	Canbelego	Cobar	Canbelego.
†1902 ...	Queen Bee	,,	Cobar.
1902 ...	Attunga	Peel and Uralla	Tamworth.
†1903 ...	Mount Royal	Mudgee	Dandaloo.
1903 ...	Underlay	,,	,,
1903 ...	Namoi	Peel and Uralla	Tamworth.
1903 ...	Al Tinby	Tambaroora and Turon	Stuart Town.
†1905 ...	Bogan River	Mudgee	Dandaloo.
1905 ...	Cowfell	Lachlan	Cowra.
1905 ...	Cash (Essington)	Bathurst	Rockley.
1905 ...	Lucky Hit	Southern	Goulburn.
1906 ...	Budgery	Cobar	Canbelego.
1906 ...	Native Bee	Mudgee	Wellington.
1906 ...	Orange Plains	,,	Dandaloo.
1906 ...	Ace	,,	,,

† Furnaces established in connection therewith.

Copper.

Atomic weight 63·4; specific gravity, 8·94; melting point, 1080·5° C. (H. M. Howe); boiling point, about 3000° C.; volatile at highest obtainable temperature in electric arc, &c. Just before melting becomes very brittle, and may be pulverised.

Molten metal has a greenish colour, also imparts green colour to oxidising flame. Absorbs certain gases when molten, which it sets free on solidifying, requiring special precautions in copper casting to prevent porosity.

Electrical conductivity, 931—silver being 1,000 (Peters); capacity for conducting heat, 898—gold being 1,000 (*ibid*).

The necessity for careful selection of ores for roasting with matte, especially if electrolysis is not to follow (and this process is also effected), is emphasised by Dr. W. Borchers and W. G. McMillan,[1] "because copper readily dissolves (when melted) aluminium, nickel, cobalt, zinc, cadmium, tin, lead, bismuth, gold, silver, manganese, chromium, tungsten, molybdenum, and iron; also various metallic compounds (cuprous oxide, sulphide, and phosphide, and the arsenides, arseniates, antimonides, and antimonates of lead, bismuth, &c.)."

In combining with sulphur copper exhibits far greater chemical energy than any other of the heavy metals. The first process of chemical concentration is dependent upon high chemical stability of copper when combined with sulphur in the melted condition.[2]

Principal solvents of copper are nitric, concentrated sulphuric acids, and aqua-regia (a mixture of nitric and hydrochloric acids). Hydrochloric and dilute sulphuric acids only dissolve the metal when air or some other oxidising substance is present.[3]

[1] Electric Smelting and Refining, 1897, p. 171. [2] *Ibid.*, p. 173. [3] *Ibid.*, p. 172.

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Copper was probably the earliest of the metals converted to human use; certainly it is the first of which relics have been discovered amongst the primitive implements of prehistoric man, and has, indeed, furnished evidence of his intellectual progression by the advance it marks in material adaptation to his needs. With the abundant celts or stone implements of North America —where native copper abounded at Lake Superior—occur similar forms in metallic copper. Probably first by hammering, and subsequently by melting, the native metal was shaped according to the knowledge of our ancestors. Later, by the addition of lead, zinc, or tin, which may first have been naturally associated with copper ores, was the harder bronze alloy obtained. The far more infusible and valuable iron—which in its native state is a rarity in nature—was still later smelted from its ores. The intellectual and industrial progress of prehistoric man has, by means of his weapons and implements, been divided by archæologists into—

(*a*) Palæolithic or Ancient Stone Age—Roughly chipped and unpolished flints and chips.
(*b*) Neolithic or Newer Stone Age—Smooth and polished flints and chips.
(*c*) Copper and Bronze Age.
(*d*) Iron Age.

The composition of a prehistoric bronze from Ireland is given by Professor Roberts-Austen[1] as copper, 83·5; tin, 5·15; lead, 8·3; iron, 3·0.

Copper, of all metals, most readily betrays its presence in Nature by the remarkably attractive colouring assumed by some of the ores resulting from its decomposition, such as the carbonates, silicates, and oxychlorides. The beautiful sapphire-blue azurite, the bright and dark-green malachite, the turquoise-blue chrysocolla, the dark-green atacamite, and the pellucid blue sulphate from solution, are specially distinctive. Mere traces of some of these minerals characteristically colour large outcrops of rock, or the dry beds and sides of channels through which cupriferous waters have intermittent flow. These superficial colourings may frequently be delusive, and entail endless labour and disappointment on the uninitiated, especially in those instances resulting from decomposition or alteration of small particles of native copper, or one of its sulphide compounds, occurring probably as idiogenetic, or original constituents, of some intrusive rock, as in the Wellington and Carcoar Districts.

Usually one of the most favourable surface indications of an extensive copper lode is abundant gossany or cellular iron oxide and quartz, stained with carbonate of copper, commonly described by old copper-miners as a "good iron hat" or "an iron saddle riding a good horse." Such an outcrop affords presumptive evidence of extensive deposits of sulphides below the zone of oxidation or water-level. But surface indications cannot be relied on as infallible guides to conditions below. The Great Cobar, Nymagee, New Mount Hope, and Burraga Mines were instances of the unreliability of any one set of conditions for all occurrences; Cobar, in particular, afforded little surface evidence of the immense bodies of payable ore beneath. The reverse also frequently holds good, large and promising outcrops capping lean and unprofitable deposits. Copper Hill, near Molong, and possibly Cow Flat Mines, may be cited as instances of failure to realise the fair promise of the outcrops so far as tested.

Though the presence of copper is usually recognisable in a gossany outcrop forming the back of a copper-bearing lode, yet its absence must not be

[1] An Introduction to the Study of Metallurgy, 3rd ed., 1894, p. 105.

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inferred from lack of the usual indications, for notable instances are not wanting of such a deficiency. According to Dr. Peters,[1] the famous Montana lode, which at the present day, perhaps, is furnishing the largest amount of copper from any single deposit in the world, down to levels averaging about 250 feet from the surface carried comparatively no copper, and was worked solely for the silver it contained;[2] it had, in fact, become a low-grade silver deposit. At the level mentioned, a rich zone of copper ore was struck between the argentiferous, yellow, quartzose cap and the leaner copper ores below. The Anaconda Mine, was, perhaps, the only exception, the rich zone being met under 200 feet from the surface. The cause of the enrichment was, doubtless, the leaching and removal of the copper from the higher levels, and reprecipitation and concentration below; the line of demarcation between the impoverished and enriched zones being sudden and distinct.

The experience gained at C.S.A., Budgery, and other mines proves the necessity of reaching water-level before abandoning prospecting. In the arid western country, where the water-level lies deep, whilst porous gossan continues in the ore channel—even with little or no other metallic association than the iron oxide—prospecting should be continued. But there is no justification for the wild idea of sinking deep simply for the purpose of cross-cutting, where there is entire absence of gossan, or channel rock, or other evidence of a metalliferous deposit.

During the C.S.A. and Budgery "booms" the popular local idea of getting down deep and cross-cutting, irrespective of the slightest indication, entailed extensive expenditure sinking holes in the ground.

Ferruginous outcrops usually make into pyritic masses or impregnated country, but do not necessarily make into copper lodes. Copper is more easily decomposed and leached than its usual associates, but generally leaves traces (stains of carbonate) to represent the transferred proportion concentrated about water-level. Where an outcrop has been leached, the resultant gossan usually becomes porous or cellular, by removal of the minerals rendered soluble by oxidation. Lead is sometimes similarly redeposited—as at C.S.A.—but generally leaves scattered crystals and bunches of carbonate in the leached zone.

Where a concentrated mass of ore immediately overlies the water-level, its thickness is proportional to the original richness and thickness of the impoverished mass from which it has been derived. Likewise the metallic values of the primitive or unaltered extension of the lode below water-level may be gauged by the vertical extent of leaching necessary to produce the thickness of enrichment.

Where pyritic and solid below water-level, the great desideratum is, sufficient copper to form a copper matte and concentrate gold and silver values.

A feature of the West Bogan (Orange Plains and Albert Water Holes), copper lodes is the very slight surface development or outcrop—a feature probably due to the flatness and aridity of the country, and consequent slight degradation and dissection. At most a few nodules, or a small patch of ironstone, form the only superficial indication. Ferruginous quartzites are occasionally moderately conspicuous, but rarely prove of any value at lower levels.

[1] Modern Copper Smelting, 5th ed., 1892, p. 16. [2] In the 7th edition the figures are 40 to 300 feet.

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The white clays and bleached rock, frequent in the leached upper levels of lodes, result from the action of soluble sulphates derived from oxidation of pyrites.

The famous Burra and Moonta Mines of South Australia also furnish evidence which counsels caution in condemning a ferruginous deposit betraying little surface indication of permanent deposits beneath.

At the Burra Mine, according to Mr. H. Y. L. Brown, Government Geologist,[1] there was no appearance of defined ore-bodies above the 180-foot level, the carbonates occurring very irregularly as nodules and investing cavities and fisures; but below the 180-foot level regular lodes were met containing very rich ores—malachite, cuprite, and grey ore.

In the Moonta Mine, according to the same authority, between a very thin superficial coating of malachite and atacamite only a few inches thick, and the 50 or 60 foot level, no further ore was met, and, as a rule, not even a stain indicated the rich oxides and malleable copper just beneath, which were succeeded by black and grey sulphides.

In the Blayney or Annandale Mine of this State, beyond a mere trace in a thin quartz vein, no copper ore was met with above the 90-foot level, though some 2,000 tons of iron ore were removed from the back of the lode for iron-smelting at Lithgow.

At the celebrated Mount Morgan Gold Mine, Queensland, practically no trace of the copper ore which is now converting it into a large smelting proposition, was visible above the 300-foot level.

Going further afield for examples, according to R. Hunt, F.R.S.,[2] in Cornwall no copper ore of any value was raised until the 180-foot or 240-foot levels were reached, and that the great mine of Przibram, in Bohemia, had to be sunk 120 to 180 feet before it became productive.

The instances quoted are sufficient to demonstrate the wisdom of continuing sinking in the cap of a copper lode until the water-level and the yellow sulphide zone are reached. The rich secondary ores, such as copper glance (grey ore) and bornite, resulting from the leaching of the higher levels and redeposition, are usually found concentrated just about water-level, and above the ordinary chalcopyrite (yellow ore). When the latter is reached little permanent alteration for the better can be anticipated, but rather the reverse; the general experience being that depreciation waits on depth.

As most copper ores occur in more or less disconnected lenses along the strike or channel of a lode, it follows that levels extending beyond the productive masses should not be too readily abandoned in blanks whilst channel conditions—defined walls with crushed filling between—continue. The same applies to shafts and winzes, for blanks occur vertically as well as horizontally.

Frequently the intervening spaces are not wholly blanks; thin seams and kernels of ore occur in the crushed filling, which may be hand-picked or concentrated to a degree suitable for fluxing more basic ores.

Main shafts for haulage must be sunk vertically, or in a straight line on the underlay, preferably in the country; but prospecting shafts and winzes should be sunk in the ore-bodies, to avoid dead or unproductive work. As levels are driven, shafts and winzes should be consistently deepened, or fresh

[1] Record of South Australian Mines. [2] British Mining, 1884, p. 305.

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ones started following the ore-lenses. The aim should be to continually have "in sight" a considerable body of "reserves" ahead of main stopes; though stoping, for judicious furnace blending, should proceed at all levels as opened up.

If this systematic development be followed there will be no danger of the bottom suddenly "dropping out" of a mine.

The cause of the occasional enrichment of the lower levels and the poverty of the cap is the greater solubility of the copper salts resulting from the decomposition of cupriferous pyrites, than those of the associated iron sulphide, which meanwhile are converted chiefly into insoluble oxides. The copper salts are thus removed by percolating waters, and carried to lower levels where precipitation in more concentrated form ensues.

An interesting instance of the relative solubility of copper, zinc, and iron is afforded in the accompanying analyses of samples of mine water from the Currowong Mine, near Lake George; the proportions of the several metallic salts manifest their differing solubility:—

	[1] Water from Working Shaft.	Water from Old Shaft.	Water from Currowong Creek.
	Grains per gallon.	Grains per gallon.	Grains per gallon.
Sulphate of Copper	1·12	17·67	6·42
,, of Zinc.....	16·98	53·54	7·20
,, of Iron.....	0·43	1·42	0·98

The sulphur compounds of copper being less stable under the chemical reactions set up by ordinary atmospheric conditions in an outcrop than those of the commonly associated metals, such as iron, lead, silver, and free gold, are frequently almost entirely removed, and redeposited at lower levels comparatively freed from the latter, which remain to enrich the leached gossan.

In the artificially-stimulated reactions of the roasting furnace, however, the reverse holds good as regards the commonest associate—iron sulphide. It is possible to remove the latter as a loose pulverulent oxide, whilst the intimately mixed copper sulphide not only remains scarcely altered, but melts and retreats to the centre of the ore lump through the porous iron oxide, a movement taken advantage of in "kernel roasting."

As Dr. Peters points out,[2] the metallurgical processes for obtaining copper from its ores are based upon its strong affinity for sulphur, wherein it exceeds every other metal. Silver frequently accompanies the leached and redeposited copper from the upper levels of lodes. Dr. Peters gives two very interesting instances of this.[3] Just below the oxidised cap of a portion of the Rio Tinto deposits (Spain) was a soft, greyish, earthy deposit from 1 to 6 inches thick, resting on the scarcely altered pyrites, which contained from 50 to 150 oz. of silver per ton, whilst the original pyrites contained about 1 oz. or less per ton.

At one portion of the Mount Lyell (Tasmania) deposit of pyrites, which averaged about 4½ to 5 per cent. of copper, with 3 dwt. of gold and 3 oz. of silver per ton, a remarkable chute of gossan descended on the footwall to the 200-foot level. It contained nearly the same amount of gold as the

[1] Ann. Rept. Dept. Mines for 1890, p. 59. [2] Modern Copper Smelting, 2th ed., 1906, p. 5.
[3] *Op. cit.*, p. 11.

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original pyrites from which it was derived, but neither copper nor silver, the latter having been leached out and redeposited on the footwall under the lower border of the gossan in a series of extensive and irregular pockets. The first 50 tons extracted averaged close to 2,000 oz. of silver per ton, and 21 per cent. of copper.

In arid tracts where denudation has not been extensive, and where climatic conditions have assisted decomposition, as at Cobar and Broken Hill, oxidation extends to considerable depths, from 250 to 400 feet in the instances mentioned; though the vertical level of alteration is never uniform, being determined by the nature of the different portions of the lodes, and the occurrence of open fissures and caverns.

One of the most striking examples of a large outcrop, and of the effects of oxidation, leaching, and partial removal, was furnished by the famous Broken Hill silver-lead lode. Its bold, rugged outcrop of manganiferous iron oxide, upwards of 300 feet wide in places, formed a conspicuous feature in the landscape prior to the introduction of the open-cut system of extraction. From the oxidised cap of this giant lode the zinc sulphide, which caused such metallurgical trouble at lower levels, was almost completely removed, leaving a kindly ferruginous carbonate of lead under the iron cover.

The potential action of circulating waters above and below permanent water-level is distinctly opposite; in the former it oxidises and dissolves, in the latter protects from oxidation, and tends to deposit rather than dissolve.

Uses of Copper.

The qualities and uses of copper are so well known that repetition is unnecessary. Reference might, however, be made to the large part it is destined to take in the increasing application of electricity to the industrial arts and sciences, owing to its great conductivity (931, silver being 1,000). The practical potentialities of electrical energy appear almost boundless, and all things point to its rapid conversion to wider and ever-augmenting demands of industrial progress. Herein lies one of the most hopeful auguries of the copper industry. At the same time, it must be borne in mind that aluminium is likely to prove a rival for electrical purposes, especially if a high price be maintained for copper. The cost of aluminium has been rapidly reduced during the past few years, whilst, bulk for bulk, copper is 3·3 times heavier than aluminium. Pure aluminium[1] has a conductivity of 63 to 64 per cent., or 630 to 640 compared with the silver standard. Aluminium wire is in use for movable telephone and telegraphic work. Its extreme lightness renders it most suitable for field military telephones and telegraphs.[2] A contract was let to supply 150,000 lb. of aluminium wire to convey power from the Shoqualme Falls to Tecoma, Washington; the metal to be alloyed with 1½ per cent. of pure copper. In connection with this subject, it is interesting to note the discovery of the most important commercial ore of aluminium—bauxite—in New South Wales. For electrical purposes copper must be practically free from impurities, as such tend to diminish its conductivity. Lake Superior copper—prepared from the native metal—enjoys the distinction of being equal, or almost so, to copper prepared by electrolysis, owing to its purity.

[1] Mineral Industry, VI, 1898, p. 39. [2] *Aust. Mining Standard*, 13th April, 1899.

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Broken Hill.

Original outcrop of lode at south end of Block 11.)

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Commercial Copper Ores.

Copper occurs in Nature in a variety of combinations with other elements, but those of commercial importance are comparatively few, and only such will be considered here.

Native Copper—Specific gravity, 8 to 8·9, when pure and solid.—Native copper is common in New South Wales wherever copper ores occur, but in no instance has it been discovered in appreciable quantities. In the oxidised zone of the Great Cobar, Girilambone, Blayney, Peelwood, Cadia, and other mines, it occurred in small irregular masses, crystalline, arborescent, and leafy forms. In the Broken Hill lode very beautifully crystallised aggregates of native copper and cuprite occurred above water-level, where also a new combination—iodide of copper—was discovered by Mr. C. W. Marsh, after whom Professor Liversidge proposed to name it "Marshite."[1]

At Reedy Spring, near Molong, on the Gamboola Estate, one of the largest blocks of native copper (1 cwt.) found in the State was discovered, and exhibited in the London Exhibition of 1851. A similar block from the same locality, weighing three-quarters of a hundredweight, is now at the station homestead. Mr. Stutchbury recorded the presence of native copper in porphyry in this locality in 1852.

It is interesting to note that at Lake Superior, U.S., masses of native copper, weighing several hundred tons, were found, the largest, according to C. Le Neve Foster,[2] weighing nearly 600 tons. These immense masses proved anything but profitable discoveries, owing to the difficulty of extraction, having literally to be sawn into blocks for removal.

In the andesitic and epidotic rocks of Wellington, Cowra, and Carcoar Districts, small, possibly idiogenetic grains, and thin secondary veinlets of native copper are present, which, owing to decomposition at the outcrops, frequently very deceptively stain large areas of rock superficially.

The presence of minute particles of native copper in the tuffaceous shales of the Narrabeen Series (Triassic) overlying the Sydney Permo-Carboniferous Coal Basin, will be found fully described in another section of this work. Is also found in a basalt at Kiama, which is regarded by Professor David as one of the probable sources of the volcanic particles in the cupriferous shales.[3]

Cuprite (Red Oxide of Copper) Cu_2O. Specific gravity, 5·8-6·1. (Composition—copper, 88·8; oxygen, 11·2 = 100).—This is the richest ore of copper, and is found in the upper portions of lodes, frequently forming a coating of native copper as a result of decomposition. Though rarely persistent in lodes, and comparatively scarce when compared with lower-grade combinations, it is yet frequently of considerable commercial importance. In the Great Cobar lode it occurred in massive bunches of great purity near the surface. At Girilambone it formed an important source of the metal in the South lode, where it occurred as "carbonas" or isolated nodules, which probably represent altered masses of native copper. In most of the copper-mines of the State it was present, but rarely, if ever, in quantity approaching the Cobar occurrence.

Melaconite (Black Oxide of Copper) CuO. (Composition—copper 79·8; oxygen, 20·2 = 100). Specific gravity, 6·2 (when solid).—This, the second richest ore of copper, though of common occurrence, has not yet

[1] Journ. R. Soc. N. S. Wales, 1892, XXVI, p. 328. [2] Text-book of Ore and Stone Mining, 1894, p. 36.
[3] Rept. Austr. Assoc. Adv. Sci., 1881, I, p. 289.

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been found in extensive deposits in New South Wales. It is frequently mistaken for the black partially altered and enriched sulphide of the transitional zone, between the thoroughly oxidised ores and the yellow sulphide below water-level, unfortunately in this state forming an incoherent powder very difficult to save in mining and dressing, hence a good deal of actual loss occurs.

Malachite (Green Carbonate of Copper) $CuCO_3 + Cu(OH_2)$ (Peters). Specific gravity, 3·7 to 4. (Composition—cuprous oxide, 71·9; carbonic acid, 19·9; water, 8·2 = 100).—Malachite is a valuable ore of copper, and one of the most common in the oxidised zone; hence it is familiar to miners, and necessitates brief notice only. In all the principal mines of the State, with the sister carbonate—azurite—it furnished considerable supplies of direct smelting ore. At Cobar it occasionally occurred fairly massive; but not sufficiently so for ornamental purposes. At New Mount Hope it occurred in rather earthy form, and as a "stockwork" of minute interlacing veins, an interesting feature of which is the secondary origin of some of the malachite veins which cross and intrude the azurite. Beautiful velvet and moss-like crystalline aggregates (sometimes stellate) frequently lined fissures and cavities in both mines. The Cobar carbonate ores are practically exhausted in the present workings; but at Girilambone, New Mount Hope, and the Central, considerable quantities of low-grade carbonates and oxides still await an economic and efficient treatment, probably other than smelting, in consequence of the excess of silica and the absence of solid sulphides.

Azurite (Blue Carbonate of Copper) $2CuCO_3 + Cu(OH_2)$. Specific gravity, 3·7 to 3·8. (Composition—cuprous oxide, 69·2; carbonic acid, 25·6; water, 5·2 = 100).—Azurite occurs almost invariably associated with malachite, but in lesser quantities, and is, therefore, common in the upper levels of copper lodes. Very beautiful radiate crystalline aggregates were obtained in the New Mount Hope and Girilambone lodes, and almost equally as fine crystals from the Peelwood and Broken Hill lodes.

Chalcocite (Copper Glance, Grey Sulphide of Copper) Cu_2S, locally known as "grey ore" amongst miners. Specific gravity, 5·8. (Composition—copper, 79·7; sulphur, 20·3 = 100).—One of the most important ores of copper, usually resulting from redeposition of copper-salts leached from the upper levels. It occurs in most of the local copper lodes. At Cobar it formed massive bunches. At the Bingara mines and at the Bumbery, some of the most characteristic examples of this ore have been obtained; usually, however, it is massive and destitute of typical structure and lustre.

Bornite or *Erubescite* (Variegated Copper Ore) $3Cu_2S$, Fe_2S_3. Specific gravity, 4·5 to 5·5. (Composition—copper, 55·58; iron, 16·36; sulphur, 28·6 = 100).—A rich ore of copper, also probably derived from the redeposition of ores leached from higher levels. It is remarkable for rich colouring (to quote Dr. Peters), from "golden yellow to deepest indigo, and from brilliant green to royal purple," which the freshly-broken purplish-brown mineral assumes on exposure to the air. It occurs sparingly in a number of localities in the State. In the Burley Jacky Mine, near Woodstock, the only important deposit was mined, upwards of £40,000 worth of bornite being raised from one chute, averaging 30 per cent. of copper. At the Hampden Mine, between Mount Victoria and Jenolan Caves, bornite also occurs; but the quantity is doubtful.

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Chalcopyrite (Yellow Sulphide of Copper, Copper Pyrites) Cu_2S, Fe_2S_3. Specific gravity, 4·1 to 4·5; hardness, 3·5 to 4. (Composition—copper, 34·4; iron, 30·5; sulphur, 35·1=100).—Copper pyrites is the most widely distributed, and in view of its persistence in depth, the most important ore of copper. The lower extensions of all copper lodes almost invariably owe their value to chalcopyrite; and conversely nearly all the ores in the surface zone have originally resulted from its decomposition. Usually it occurs associated with iron sulphide (pyrite) as a mechanical mixture. In the most important deposits the iron pyrite constitutes the chief lode mineral, and generally carries small proportions of gold and silver, which are recoverable under metallurgical treatment. In the descriptive notes on Working Mines, particularly in connection with smelting and concentration, where it occurs sparingly and independently disseminated through the gangue, this important ore will be fully discussed.

ABANDONED MINES.

An endeavour was made in the first edition of this work to give the fullest possible information obtainable under the circumstances of the nature of the ores and the extent of development of the early-opened copper mines of the State, the sites of many of which were marked only by old mullock heaps, slag dumps, and ruins of furnaces. The value of these records of the dead past may not at first glance be apparent; but viewed in the light of the successful reopening and working of mines at the present day which in the past had a fluctuating existence, neither the time nor the effort was in vain.

In the early days of copper mining and smelting in New South Wales lean ores were either disregarded in mining or discarded in sorting, only such as would pay to smelt direct at the mines, or cover the higher additional cost of carriage and smelting at some central works, being handled. The early miners had further to contend with enormous initial outlay consequent upon long carriage by teams over bad roads (over 300 miles in the case of Cobar, for which as high as £42 per ton was paid) to the nearest railway; conservation of water, in some instances in arid country destitute of natural drainage channels; in fact, in almost every essential for development an outlay was incurred altogether disproportionate to the cost of similar requirements in these latter days of extended railways and cheaper freights and fuel.

The successful working of the far Western mines under these abnormal handicaps for a number of years is eloquent testimony to the richness of the ores near the surface, as well as to those of mines nearer the seaboard, opened in earlier days under rather more favourable conditions as regard distance of carriage and of water supply.

Exhaustion of these richer oxidised supplies, and encountering with depth the more permanent but greatly poorer sulphides below the water-level, in many cases compelled abandonment, in some instances abruptly when the position was aggravated by a sudden drop in the market value of copper.

It may be approximately stated that, even under existing local conditions, a return of less than £55 per ton to the producer will not afford a margin for profitable working, except, perhaps, in the case of ores capable of treatment on a large scale.

In view of the modern advantages of cheaper freights (which are a *sine quâ non*) and improved processes and machinery, which tend to counterbalance depreciating yields by larger and more rapid output, it

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is reasonable to anticipate that mines closed owing to adverse circumstances, rather than exhaustion, will yet yield profit for capital invested. It must, however, be strongly emphasised that successful reopening is dependent not only on the size of the low-grade ore-body, but to a larger extent perhaps on its composition, which determines the possibility of direct furnace treatment or mechanical concentration. Direct or partial pyritic smelting affords the most economic and rapid reduction of quantity, which is an indispensable factor in low-grade problems.

Not only in working the present active mines, but also in reopening old ones from which the richer surface ores have been removed, every advantage offered by cheapened freights and fuels, more efficient processes and machinery, combined with strictest economy in mining and supervision, must be utilised to offset gradually depreciating ore tenor, increasing haulage, and augmenting water, which assuredly wait on depth.

Nor should the value of the accumulated mine water be overlooked when reopening after years of enforced idleness, for it becomes saturated more or less with soluble salts of copper, which can be readily and cheaply extracted by means of metallic iron. The affinity of the sulphuric acid in the solution for iron being stronger than for copper, the latter is expelled in the metallic state, whilst the former enters into combination with the acid. Therefore, before unwatering, provision should be made for testing the quantity of copper in solution, and for preparation of vats lined with old scrap-iron for precipitating the metal, if the proportion is sufficient for profitable extraction.

The recent experience of the Blayney Copper Company is an instance in point, 67½ tons of cement copper were obtained by precipitation whilst unwatering the workings, the percentage of copper in the accumulated water amounting to 32·9 lb. per 1,000 gallons.

As little free acid as possible should be present in the solution, otherwise a larger quantity of iron is dissolved without increasing the precipitation of the copper. Theoretically, according to Dr. Schnabel, 88·8 parts of iron are required to precipitate 100 parts of copper; in practice, however, the consumption of iron is considerably greater, owing to the presence of free acids.

The precipitating tanks at Rio Tinto are of bri[illegible] lined with plaster of Paris, and inside this with asphalt or Portland cement. Size, 6 ft. 6 in. x 6 ft. 6 in. x 2 ft. 6 in. The solutions traverse a series of these tanks. The consumption of iron is 1·12 parts to 1 part of copper.[1] Mount Morgan employs cemented tanks.

At the Gulf Creek Mine, near Barraba, coke, in contact with iron, was found to be an effective precipitating agent.

An analysis by Mr. W. A. Dixon, F.C.S., F.I.C.,[2] of the Milburn Creek drainage water yielded copper at the rate of 328·9 grains per gallon, equal to 4·698 lb. per 100 gallons. The iron and steel tools left in the mine during suspension owing to litigation were converted into hollow shells of metallic copper. A winch was similarly converted in the Blayney Mine.

Many old mines are on land acquired by mineral conditional purchase. There is little doubt that few of the mines so situated would remain unexplored if provision were made in the Consolidated Mining Act for ascertaining, as far as possible, by prospecting, the necessary valuation before resumption.

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[1] Handbook of Metallurgy, by C. Schnabel; English translation by H. Louis, 1898, I, p. 242.
[2] Ann. Rept. Dept. Mines for 1879, p. 87.

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Development.

Perhaps the most noticeable and regrettable feature in the early workings of the majority of New South Wales mines, and, unfortunately, of many of the present also, is the almost, if not complete, absence of anything approaching system. Sufficient unto the day has been, and is, the evil thereof. Where rich ores occur the paramount object appears to be depletion, as speedily and cheaply as possible, without regard to the future. Rarely is a payable mine opened systematically by extending prospecting operations beyond actual stoping; in fact, proving almost invariably ceases at the very time it should be most vigorously prosecuted, viz., when dividends are being paid; and perhaps still more rarely is any reasonable portion of the latter set aside as a reserve against contingencies. Hence, when the richer ores are exhausted, or the known pay-chute ends, calls are necessary for improvement of plant, or the search which should have been synchronous with payable working.

Dr. Peters states[1] that the rich ores of Butte, U.S., furnished the capital that was needed to design and construct the improved plants, and to gain experience necessary for treating the lower-grade ores at a profit; unfortunately, this has not been the case with certain well-known copper-mines in this State.

The necessity for timely proving is peculiarly essential in copper-mining, if any enlightened and progressive system is to be adopted in lieu of the hand-to-mouth policy which robs the mine of its richer ores, leaving the poorer to bear alone the steadily increasing cost of extraction and possibly of treatment. A more reasonable method would appear to be that which speedily opens up the sulphide resources beneath the richer oxidised and secondary ores of the surface zone, and not alone in depth, but longitudinally and laterally, proves the deposits and the barren intervening blanks.

One of the first requisites is proof of the vertical extent of the richer ores of the oxidised and redeposition zones, and the nature and quality of the poorer but more permanent sulphides beneath.

The oxidised and sulphuret ores are natural fluxes one for the other; hence it would appear more profitable to open up the latter and work them with the former, as far as these are available, instead of procuring barren fluxes, often at considerable cost, and thus introducing into the furnaces unproductive material, and thereby proportionally lessening their useful capacity.

Again, the necessity for timely proof of the nature of the sulphides, or rather of their matrix, is clearly an urgent matter, for frequently, as at Mt. Hope, Great Central, Girilambone, &c., concentration, with its attendant costs, has to be faced. Few mines offer the exceptional advantages of a Great Cobar or a Nymagee, where the solid pyritic matrix affords a kindly fluxing base in blast-furnace treatment; and, moreover, offers a ready and efficient means of treating gold and silver ores as fluxes in the process. This important advantage will be more fully discussed when the above mines are under description.

Apart from the metallurgical advantage derivable from proper blending of the different grades of ore in a mine, another equally desirable end is gained, viz., regularity and equality of output, which alone render mining a sound and secure investment. Command of rich and poor ores

[1] Modern Copper Smelting, 9th edition, 1898, p. 19.

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in a deposit may, unfortunately, be also used for the ignoble ends of market riggers and share gamblers; but fluctuating yields, either through lack of system or through design, must always react at the expense of legitimate mining and security.

Shortness of initial capital and the natural desire to make a mine "pay from the start" are frequent sources of after trouble and avoidable expenditure, leading to depletion of the richer and kindlier ores of the surface zone, and saddling the leaner and predominating with entire cost of suitable reducing plant.

It cannot be too strongly emphasised that it is the lean, and not the rich, which should determine the character of the plant; also that the often extremely narrow margin between profit and loss is dependent on the scale on which the low grades can be handled.

From these premises it is clear that the first duty is to pierce the enriched zone, and ascertain qualities and probable quantities of primitive ores below the protecting water-level. In this way only can an intelligent insight into the smelting problem be obtained, and the fullest advantage of natural fluxing secured.

Determination of these important questions should be followed by installation of plant commensurate with nature and quantity of reserves disclosed.

Establishing a smelting plant prior to adequate proving, unfortunately, is still not uncommon, leading to a hand-to-mouth existence wherein smelting is dependent on the daily mining output, and the latter on the exigencies of blind stoping.

The Crowl Creek-Shuttleton Mine is a case in point, where the daily requirements of the established furnaces overtaxed the output of the proved ore lens, preventing prospecting ahead of actual stoping. Difficulties, moreover, become accentuated when, as frequently happens, the primitive ores are not amenable to direct furnacing.

Trafficking in shares during the "boom" period of a mine's history frequently imparts an entirely false idea of its financial strength. The inflated value of its stock on the market is no criterion of the capital available for development, which only too often is absurdly inadequate for placing it on a proper working basis.

The sudden shock of a call for necessary developmental expenditure is like a "bolt from the blue" to uninquiring investors who bought at the top of the market. It should be a *sine quâ non* that a sufficient sum for the purpose should be secured against promoters' interests in the paid-up capital, and no better time for this than when confidence is strong. Again, in all legitimately-worked mines a reserve fund against contingencies should be established out of profits.

Brown and Turnbull, writing on this subject, state: "It must, however, be always remembered that much time and generally much more money than is at first anticipated have to be expended in the initial stages of development before any results are obtained that make for permanence or a reasonable prospect of such. To neglect the patient application of those scientific principles by which a new field can be laid out so as to ensure such a regular output as may be commensurate with the importance of the undertaking, the creation of reserves of ore, and the deciding on erection of a suitable plant, is but to court disaster."[1]

[1] A Century of Copper, 1900, Pt. II, p. iv.

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Dr. Peters states: "It is impossible to make any calculation about the probable behaviour of an ore in the blast furnace, or indeed any other, until we know its exact chemical composition." Hence the necessity for securing qualified metallurgical knowledge and skill when smelting is determined upon. Ordinary furnace experience may be sufficient where only the simplest and richest ores are to be dealt with, but as these should form the vehicle for inferior and refractory associates, correct blending is dependent on exact knowledge of chemical affinity and equivalence.

Where, for instance, rich basic (sulphide) ores occur in the enriched zone, these should afford the means for furnace concentration of leaner ores mixed with country or gangue. Mechanical concentration should be the last resort in such cases. Likewise, where oxidised ores are available, it is preferable to use them with raw sulphides instead of roasted sulphides.

Peters says: "Fluxes need hardly ever be used if the analyses of ores are studied metallurgically. Sometimes, however, silicious fluxes containing gold and silver can be used with great profit." Silicious ores require ferruginous flux, and *vice versâ*.

Every ton of barren flux increases cost of smelting. Recent turning to account of grades, previously unthinkable of as profitable smelting propositions, is owing to the great advance in economic mining and reduction, notably, in this State, the Burraga silicious ore of 2¾ per cent., and Great Cobar (basic) of 2·7 per cent.

Falls in copper value are not altogether unmixed evils, for they have been the spurs to greater efforts to reduce costs, compelling increased efficiency and economy, which ensured greater profit in periods of enhanced value.

It is worth considering whether advantage should not be taken of "boom" times to work the lowest grades, leaving the richer for exploitation when values are lower, thus lengthening the life of the mine.

Brown and Turnbull, in their review of the copper-mining industry during the past century, state: "The most remarkable feature next reviewed is the great reduction which has taken place in costs.

"The average 'copper contents' of the various classes of ore are shown, and while it is to be observed that they are on a declining scale throughout, the adaptation of improved methods of treatment of a necessarily increased bulk more than compensates for the falling off in percentage. It will be seen that, approximately, the cost of making copper has been reduced during the century (in the case of sulphide mines using the smelting processes) from £80 per ton to £40 per ton of metal." [The great scale of operations at Mount Lyell (Tasmania) enables blister copper to be produced at about £33 per ton from 2 per cent. ore.—J.E.C.]

"It has been to an increase from the older sources of supply, such as Lake Superior, Montana, and Arizona, that the constantly increasing consumption has had mainly to depend upon for several years past.

"To the older smelting methods have been added blast furnace, water-jacket furnace, Bessemer converters, pyritic smelting, and enlarged reverberatory furnaces; while an entirely new type of refining has been introduced by the electrolytic method, which not only refines the copper, but recovers the gold and silver contents in the same operation."[1]

[1] A Century of Copper, 1900, Pt. II, p. iii.

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Low-Grade Deposits.

Until the Cobar Mining Syndicate began operations in 1893-4, when local copper was realising but £39 per ton, the successful treatment of low-grade copper ores was solely dependent upon the value of the copper contents, no allowance being made by purchasers for the associated gold and silver in certain brands of copper, which must have been an important source of profit to them. This serious defect was soon remedied, the full market values of the associated metals, less cost of extraction, being obtained. Still the additional advantages enjoyed by European smelters of realising the values of by-products is not yet possible to those of Australia. The Tharsis Copper and Sulphur Company, of Glasgow, affords, perhaps, the most signal example in this respect. Working the low-grade cupriferous pyrites of the Spanish Peninsula, containing barely 3 per cent. of copper, and traces only of gold and silver, it was enabled, through realisation of the by-products, to pay dividends of 750½ per cent. on a capital of £1,250,000 between 1868 and the end of 1905. Theoretically, the only loss in its operations is the scrap-iron used in precipitating the copper from solution, each of the component minerals in the ore being turned to commercial account. A short description of the interesting Tharsis process, from notes made by the Writer during a visit to the Company's Glasgow works in 1890,[1] may prove of interest:—

"During my stay in Glasgow, through the courtesy of the proprietary, I was enabled to visit the Tharsis Copper Reduction Works. The Spanish ore treated at these works consists chiefly of iron pyrites with a percentage of copper pyrites equal to about 3 per cent. of metallic copper; the sulphur being equal to from 46 to 48 per cent.; very small quantities of gold and silver are also present. The ore is first roasted at the Sulphuric Acid Works, in the immediate vicinity, to obtain the sulphur, about 4 per cent., however, being purposely left in the calcined ore; it is then mixed with 16 per cent. of salt, and charged into roasting furnaces in charges of about 3½ tons, exclusive of the salt. The furnaces are known as blind muffles, the ore being within a central brick oven out of contact with the flames. The roasting continues for about ten and a-half hours. The fumes are led from the muffles into towers containing coke, over which water is constantly trickling, which absorbs the gases given off. A small proportion of gold is carried down in the acid solution, and is precipitated along with the other metals present by a small quantity of sulphide of calcium, which is allowed to trickle into the solution at the points where it issues from the base of the towers into the settling vats. The clear acid solution, which contains about 30 grains of copper per gallon, is in part used for washing the roasted ore, the balance being treated with scrap-iron to precipitate the copper.

"The roasted ore is thrown into vats, and hot water pumped on to the top; as it percolates through the mass it dissolves the soluble copper salts formed by roasting; the copper solution passes through the filter bottom into the adjoining compartment. The ore is then discharged into another vat and rewashed, the weak solutions being constantly charged into the ore vats until they attain a certain strength. The gangue is washed until no appreciable quantity of copper is left; the completely decopperised gangue, after exposure and oxidation, is known as "blue-billy," and is sold to the iron foundries for fettling purposes. The strong copper solution is pumped into vats and treated with iodide of zinc to precipitate

[1] Ann. Rept. Dept. Mines N. S. Wales for 1890, p. 278.

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the silver; the solution is after a time drawn off and treated with iron scrap to precipitate the copper in the metallic state; the resulting copper scale is washed and then smelted into ingots.

"The precipitates obtained with the sulphide of calcium and iodide of zinc are sent to Birmingham for treatment. In the above interesting and economic process there is, therefore, no waste, save the unavoidable losses of manipulation, all the commercial constituents of the ore being extracted."

A day at Cobar or Lithgow is forcibly convincing of the great, yet probably unavoidable, loss of valuable material, viz., sulphur, that is being continually volatilised into the atmosphere. Unfortunately, local conditions prevent its utilisation in the manufacture of sulphuric acid, as is sometimes the practice of European countries, where protection of vegetation, apart from commercial advantage, compels preventive measures against the disastrous effects of sulphuric acid gas, more particularly in humid climates. Fortunately, or unfortunately, little loss is likely to accrue from the latter cause at Cobar.

Where smelting operations are carried on in centres of population, the fume nuisance is capable of abatement by erection of tall chimney-stacks, by means of which the noxious gases become largely diluted with air before reaching the ground. Experiment has proved that the other volatile substances discharged into the atmosphere in copper-smelting are practically inert, or too diffused to be objectionable.

The monosulphide—pyrrhotite or magnetic iron pyrites—which is common in copper lodes, and in considerable proportions in some of those of the Blayney District, and is also present in the Cobar lode, is of little value for sulphuric acid manufacture, as it contains but one atom of sulphur against two in the ordinary pyrite, and requires greater heat for its expulsion. It is, however, of equal calorific power to the bisulphide in pyritic smelting, owing to the volatilisation of one atom of sulphur from the latter in the native state.

Of recent years, large bodies of low-grade cupriferous sulphides have been much sought for, the most important ventures in this direction being the Mount Lyell, of Tasmania, and the Great Cobar, of New South Wales.

How low a grade may be profitably exploited depends upon local conditions and the nature of the ores. If gold and silver be present, even in comparatively insignificant proportions, an ore capable of pyritic treatment on a large scale, cohtaining even 2 per cent. of copper, will yield a profit under favourable circumstances (especially of transport). It is, indeed, remarkable upon how little depends the profitable or unprofitable operation of such deposits on a scale of great magnitude; the almost infinitesimal gold and silver contents may represent the difference between profit and loss. Even at the famous Butte Mines, of Montana, U.S. (according to Dr. Peters[1]), it may be assumed that the net profits are mainly derived from the silver contents, which amount to about 5 oz. per ton of 2,000 lb., in copper ore then averaging about 6½ per cent. Deducting the losses in concentration and smelting, the net yield of the Butte ores was 5 per cent. of copper and 4 oz. (0·014) per cent. silver,[2] the present yield being about 3¼ per cent.

The smelting yield of the Great Cobar ore is estimated at the present time to average about 2·7 per cent. of copper and 2½ dwt. of gold per ton.

[1] Modern Copper Smelting, 9th ed., 1898, p. 20. [2] *Ibid.*, p. 19.

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The actual returns of gold and silver are, however, difficult of estimatio owing to complication arising from admixture of gold and silver or from the neighbouring Great Peak Mine as fluxes.

In one respect, auriferous, low-grade copper deposits possess a distin advantage over richer, viz., the extreme smelting concentration necessar to produce a profitable matte from poor copper ores brings their sma gold and silver contents within the range of profitable extraction, whic is an impossibility in low concentration, owing to the cost of electrolyt separation. The ratio of concentration during the two campaigns Lake George Mines (Ltd.), Captain's Flat, averaged 27 tons of ore 1 ton of 30 per cent. matte.

The proximity of silicious flux, having of itself considerable value, an important factor in the determination of the profitableness of an low-grade pyritic lode.

The regrettable failure of the operations of the Lake George Min turned on 1 per cent. of copper. The pyritic smelting adopted, after th initial difficulties had been overcome, reached so high a pitch of economi efficiency that a smelting yield (according to the Company's certifie returns) of a shade over 1 per cent. of copper, and proportionately sma yields of gold and silver, amounting in aggregate value from 22s. to 23s. only failed by about 5s. 6d. per ton to pay cost of mining and smelting An additional percentage of copper at the market rate would have turne the balance between profit and loss.

The failure of the Company's first operations resulted in the achieve ment of further reductions in cost of production, under the skilful treat ment of Mr. A. W. Hudson, which, combined with strictest economy i mining and supervision, established a record.[1] This result is best appre ciated after a study of the refractory composition of the ore in question which is fairly represented in the following analysis by Mr. H. P. White F.C.S., Assistant Analyst to the Department of Mines and Agriculture,[2] of an average sample selected by Messrs. Jaquet and Watt, Geological Surveyors, from the various exposed faces at the 400-foot level:—

ANALYSIS.

Moisture at 100° C.	0·10
Combined water	0·65
Insoluble in acids (gangue)	23·70*
Metallic iron	17·75
,, zinc	14·50
,, lead	8·04
,, copper	1·11
Sulphate of lead ($PbSO_4$)	0·32
Alumina (Al_2O_3)	1·38
Lime (CaO)	0·40
Magnesia (MgO)	0·65
Sulphur troxide (SO_3)	0·25
Carbonic acid (CO_2)	2·08
Phosphoric acid (P_2O_5)	0·57
Sulphur (S)	27·97
Oxygen, and undetermined	0·53
	100·00

* NOTE.—91·35 per cent. of the gangue consists of silica, the remainder containing alumina, magnesia, and alkalies. The gold contents averaged 1 dwt. 12 grs., and the silver 2 oz. 8 dwt. 14 grs. per ton.

The actual smelting returns from over 90,000 tons of ore, subsequently furnaced by the Company, verified the accuracy and thoroughness of the sampling represented by this analysis.

[1] Which, according to the Company's State representative, was 14s. 9d. per ton of ore for mining and reducing to matte and general expenses.

[2] Ann. Rept. Dept. Mines and Agric. for 1897, p. 21.

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For comparison it is interesting to note the cost of mining, smelting, and development at Mount Lyell, Tasmania, about the same date. For the half-year ending 31st March, 1897,[1] the following costs are quoted :—

	£	s.	d.
Mining operations	0	2	4·64
Removal of overburden	0	2	0
Smelting operations	0	17	9·87
Converter	0	2	9·18
	£1	4	11·69[2]

Deducting the converter charge, the cost of producing a 50 per cent. matte amounts to £1 2s. 2·51d. per ton of ore treated. The Mount Lyell ore is, however, favourably distinguished from that of Lake George Mines, by greater richness and freedom from refractory associates.

Abundance and a kindly matrix are indispensable conditions in low-grade deposits; the dimensions should be such as to allow of continuous economic winning without excessive deadwork.

The composition of the matrix and the proportion of sulphur are the important factors, for upon these depend the nature of the treatment. If largely pyritic, smelting is greatly simplified, the partial pyritic process being most suitable and economic.

A silicious (quartz) matrix, from its great infusibility and consequent heavy fluxing requirements (2 lb. of basic flux to 1 lb. of silica), is, perhaps, the most intractable. The silica, however, should be kept above 24 per cent. A deficiency of silica or excess of iron in the slag interferes with the separation of the matte, as it increases the specific gravity of the former.

With pyritic ores a considerable amount of silica—from 30 to 40 per cent.—can be safely included in the blast-furnace charge, to form a fluid silicate of iron slag. The range of silica in an ideal slag lies between about 30 and 38 per cent., but it is unquestionable that a considerably higher limit is possible. This interesting and important question receives more extended consideration in the second part of this work, under the head of Great Cobar.

Ores containing an excess of silica and deficient in iron and sulphur are better suited for reverberatory furnaces, as a large proportion of unfused quartz can be floated off in the slag of a reverberatory furnace without impairing the separation of the matte. Lean silicious sulphide ores, however, require concentration before effective independent smelting is possible. Oxide of iron, or, better still, ferruginous slag from matte roasting, is the best flux for silica.

The following *résumé* from a paper on Copper Smelting, by Mr. H. M. Howe, A.M., S.B.,[3] on the advantages of the two forms of furnaces—cupola (blast) and reverberatory—is extracted from "Modern Copper Smelting," Fifth Edition, 1892, p. 258 :—

FURNACES.

For smelting ore the cupola is specially advantageous—

"1. With highly ferruginous ores.

"2. Where the cost of anthracite, coke, or charcoal is not excessively greater than that of bituminous coal, wood, and other fuels fitted for the reverberatory only.

"3. For oxidised ores.

"4. For low-grade native copper.

"5. Where, as in the case of lean ores, clean slags are a necessity."

[1] Tasmania and its Mineral Wealth; special edition of *Austr. Mining Standard*, 1st July, 1898.
[2] Mt. Lyell has now reduced cost of mining, smelting, and bessemerizing to 15s. 4d. per ton of ore. Half-yearly Report, 31st March, 1908.
[3] Bull. U.S. Geol. Survey, 1885, No. 26.

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The reverberatory is especially advantageous—

"6. With highly refractory silicious, aluminous, calcareous, or magnesian ores.

"7. Where the composition of the ore changes suddenly and greatly.

"8. Where bituminous coal, wood, or other reverberatory fuel is very much cheaper than anthracite, coke, or charcoal.

"9. For smelting and immediately refining rich native copper.

"10. Its disadvantages in yielding richer slags than the cupola weighs less heavily in case of rich ores."

The application of the principle of pyritic, or partial pyritic, smelting is of very recent date, and in Australasia but five instances are known to the Writer, viz., at Mount Lyell, Captain's Flat, Great Cobar, and Nymagee. As, therefore, pyritic smelting is comparatively little known, rather full extracts have been made from the writings of Dr. Peters, junior, and Mr. Robert Sticht, of Montana, illustrating its principles, scope, and results.

Pyritic Smelting.—"Pyritic Smelting—Its History, Principles, Scope, Apparatus, and Practical Results," is the title of a very interesting and instructive article by Mr. Robert Sticht,[1] from which extracts have been made, as well as from the chapter on the same subject by Dr. Peters,[2] To quote the latter: "Mr. W. Lawrence Austin, of Denver, Colorado, is fully entitled to the credit of carrying out to a commercial success the principles that John Hollway, of London, proved to be practicable" (in 1878, according to Sticht.—J.E.C.).

Pyritic smelting is defined by Dr. Peters as "the fusion of sulphide ores by the heat generated by their own oxidation, and without the aid of extraneous heat, such as carbonaceous fuel, the electric arc, &c."

Its object, according to Mr. Sticht, is "to make the pyritic, or other sulphuretted materials of the ores, act in a unique and threefold capacity, viz.:—

"1. As a fuel.

"2. As a collector of the precious metals, as also of the copper, nickel, &c., present.

"3. As a flux, or slag-making factor."

From Dr. Peters' summary of pyritic smelting the following abstracts are taken:—

"1. Genuine pyritic smelting (without the aid of any carbonaceous fuel) demands exceptionally favourable ores.

"2. Partial pyritic smelting, with the aid of a hot blast, and the addition of from 1·5 to 5 per cent. of coke to the charge, is an assured success, and may, under proper conditions, be the most economical method that can be employed.

"3. Both pyrrhotite (magnetic pyrites) and matte make excellent materials for this process, pyrrhotite affording practically about as much heat as does iron pyrites, owing to the loss of the first atom of sulphur in the latter mineral, by volatilisation as metallic sulphur. The oxidation of the iron probably furnishes as much effective heat as the burning of the remaining atom of sulphur.

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[1] Peters—Mod. Copper Smelting, 9th ed., 1898, pp. 396-401. [2] *Ibid.*, pp. 372-396.

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"4. Arsenic and antimony are more thoroughly removed, and cause less trouble than in ordinary smelting. Zinc and lead sulphides are about equally deleterious in the new, as in the old, method of smelting. Heavy spar works particularly well in a pyritic furnace, the baryta being slagged and the sulphuric acid decomposed and escaping as gas, instead of augmenting the quantity of matte, as in ordinary blast-furnace work.

"5. The recovery of the precious metals is as good in pyritic as in ordinary smelting, and the slags are equally clean.

"6. The rate of concentration is very satisfactory under proper conditions, and can, in the main, be regulated at will, according to shape of furnace, volume and pressure of blast, fusibility of charge and rapidity of driving, and amount of carbonaceous fuel added.

"7. A plant for pyritic smelting can be erected at least as cheaply as one to produce similar results by the ordinary methods."

The advantages of pyritic smelting are (*a*) the enormous saving effected in cost of fuel as compared with ordinary blast and reverberatory methods; (*b*) saving the initial cost of roasting or calcining plant, with the labour attaching thereto, and the additional handling of the ore; (*c*) the production of cleaner and more silicious slags, the latter an object of great importance in many localities (Cobar, for instance) where gold and silver ores can be worked with the copper, for by keeping the slags silicious these metals may be concentrated to any reasonable extent.

In rare instances, where the ores are very suitable, carbonaceous fuel can almost entirely be dispensed with; usually, however, from 3 to 5 per cent. (coke) is used. In ordinary smelting in the United States, Dr. Peters estimates the proportion of coke in the blast furnace as fully equal to one-sixth of the weight of ore; and the combined cost of fuel in roasting and smelting as about equal to 60 per cent. of the total cost, the difference in cost of fuel between pyritic and ordinary blast furnace smelting being equal to 40 per cent. in favour of the former.

At Mount Lyell almost pure pyritic smelting is in progress, 1¼ per cent. of coke only being used.

The Writer tenders appreciative thanks to the Directors of the Great Cobar and Lloyd Copper-mining Companies for generously permitting their General Managers, Messrs. G. H. Blakemore and W. H. Corbould, giving the mining public the benefit of local experience—the former for his article on electrolytic copper-refining, and the latter on treatment of copper ores.

In commending such a policy to the Institute of Mining and Metallurgy, London, Professor James Douglas, an American copper authority, stated: "The ridiculous secrecy maintained at so many of the metallurgical works, especially in Europe, benefits no one, least of all those who sedulously close their works against inspection, and at the same time bigotedly close their own minds against all reasonable expansion. It stands to reason that there must be in art, as well as in science, a give-and-take rule; and people who will contribute nothing to the information of the world or their co-workers in any given art are not those who are generally most progressive in their own practice."[1]

[1] A Century of Copper, Pt. II, p. iv.

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Brown and Turnbull state that "these economic advances being so great, and the displacement of old processes so rapid, it is of the utmost importance that all facts connected therewith should be fully disclosed."[1]

To the Lloyd Copper Company the Writer is also indebted for working plans of the large reverberatory at the Lloyd Copper-mine (the largest wood-fuel furnace in the State), and of the "W. Thomas" small reverberatory, suitable for small mines. The working details of construction are of special value to those contemplating smelting, who will doubtless appreciate the generosity of the designers.

The symmetry of the Lloyd furnaces is most noticeable, even after long smelting campaigns—a fact due, according to the designers, to the solid foundation and thorough under-bracing.

Treatment of Copper Ores.

(By W. H. Corbould, Managing Director, The Lloyd Copper Company, Ltd., New South Wales.)

"In considering the best method of treatment for copper ores, one must be guided by the value and character of the ore, the facility for securing fluxes, the cheapest class of fuel obtainable, and the nature of the water supply.

"*Blast Furnace Treatment on Oxidised or Part Oxidised Ore or Calcined Sulphide Ores.*

"The slag from such ores should have a composition of, say, 30-35 per cent. silica, 30-40 per cent. ferrous oxide, 8-20 per cent. lime, or fluxes must be obtainable to produce same.

"Coke and delivery of same must be at a rate in keeping with the value of the ore.

"Water, suitable and in quantity for boilers and cooling water-jackets, must be obtainable.

"If the furnace is to run on oxidised ores, and the grade of the ore will not stand a high loss of copper in the slag, sulphide ore must be obtainable.

"*Blast Furnace Treatment on Pyrite Ores.*

"The slag from such ores will, to a great extent, form its own composition of slag.

"For direct pyrite (sulphide ore) smelting, the height of the furnace column should be increased over previous method, and the air capacity of the blower must be much greater.

"The ore must carry sufficient free silica, or free silica must be added to the charge, as it is the free silica available with sufficient blast that produces the necessary grade of matte, without which one would be simply melting the ore without deriving any concentrating of the copper in the matte.

"*Reverberatory Furnace Treatment on Oxidised or Part Oxidised or Calcined Sulphide Ores.*

"Should the ores be sulphides, they should be calcined to drive off excess sulphurs, leaving about 8 per cent. of sulphur in the ore. If smelting oxidised ores, and if necessary commercially to produce a clean slag, a certain quantity of sulphide ore must be available. There must

[1] A Century of Copper, 1900, Pt. II, p. lv.

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be ample fireclay in the district, or inferior clay and sufficient quartz to produce an artificial fireclay for brick-making. For fuel there must be abundance of firewood or coal at a reasonable rate.

"The advantage of this method of treatment over blast furnace is when the ore is very silicious and fluxes are unobtainable, as a slag high in silica and alumina can be worked. Very often reverberatory slag will go 48-55 per cent. silica and 10-13 per cent. alumina, and still carry more silica and silicate of alumina as float, *i.e.*, the iron and lime in the ore has taken up as much silica and alumina as it possibly can, still is fluid enough to carry in suspension more free particles of silica and silicate of alumina.

"In the construction of reverberatory furnace, one must take into account the class of slag that will be produced and the grade of the matte. If the grade of the matte will be, say, 50-55 per cent. copper, and the silica in the slag, say, 48-55 per cent., a narrow hearth, say, 13 feet wide, is the best; but if the grade of matte is not to be over 40-45 per cent., and the silica in the slag, say, about 35 per cent., and low in alumina, a hearth up to 20 feet wide would result in economy in treatment. The length of the hearth, with wood for fuel, will do good smelting up to 50-55 feet long, and I consider safely up to 70 feet if the grade of the matte is not over 45 per cent., and the silica 33-35 per cent., and alumina not over 7 per cent. With coal for fuel and suitable slag, there is no reason why the hearth should not be in the vicinity of 100 feet long. (At the Anaconda Copper Company, U.S.A., they have reverberatory hearths up to 115 feet long and 19 feet wide, smelting 300 tons of ore per day.)

"*Wet Concentrating.*

"The gangue must liberate itself from the ore previous to or at 400 holes to the square inch.

"The ore must be in a state of metallic, oxide or sulphide ore of copper (sulphide of copper that is part decomposed or been leached from upper level and redeposited as a sulphide, is often next to impossible to concentrate).

"*Oil Concentrating.*

"The ore must be in a state of sulphide, and which, on crushing, can be liberated from the gangue.

"*Magnetic Concentrating.*

"Ores that are magnetic, or that on heating at a low temperature become magnetic, and show a different degree of magnetic attraction from their gangue.

"*Leaching.*

"Ores that on exposure to the atmosphere and moisture decompose within a limited time; or where the ores are oxidised and sulphuric acid cheaply obtained, or ores amenable to roasting with common salt to form a soluble copper salt.

"The foregoing give a rough sketch of the different methods, and in installing new methods one must be guided by the commercial aspect; it is not a plant one requires, but profits. It is no use erecting a blast furnace if there is cheap and ample firewood available, coke expensive, and water scarce; or if the ore decomposes readily, there is no use in going in for an expensive smelting plant. Again, if there is not sufficient sulphur in the ore for direct pyrite smelting, there is no use expending money on high-pressure blowers.

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"It is often brought against wet concentrating of silicious sulphide copper ores that it is impossible to make a good extraction. A good mill will lose ·8 to 1 per cent. of copper in the tailings. It does not matter if the ore to be concentrated goes 5 per cent. or 3 per cent., the loss will be about the same, as the extraction is not in ratio to the grade of the ore; in fact, often on the higher grade ore the tailings are cleaner.

"The concentrates and picked ore from above, after calcining and smelting, will produce, say, a 45 per cent. matte.

"Instead of concentrating the above ore, it is smelted direct, and to smelt same it requires for each ton of ore, say, 2 tons of flux, and the grade of the matte produced is the same as the former method, viz., 45 per cent. The slag from such a grade of matte would go ·5 per cent. copper; but to flux the ore it is necessary to use 2 tons of flux with each ton of ore, which combines with the gangue in the ore to form a slag, and as each ton of slag carries ·5 per cent. copper, the loss of copper per ton of ore would probably be greater than the former method of concentrating and smelting the concentrates obtains, to say nothing of the extra cost.

"The question of costs per ton of ore does not count in copper-mining. The question is: what does it cost to produce per ton of marketable copper? and this depends on the size of the ore-body, the percentage and class of copper in the ore, management, and plant.

"A low-grade mine of sulphide ore may be worked to just meet expenditure on 100 tons per day; but if the size and length of the ore-chutes will warrant a large plant to treat 500 tons per day, it is then a question of the necessary capital to place the mine in the dividend stage.

"A concentrating proposition, yielding metallic copper even if of low grade, say, 1·5 per cent., with a good-size lode and large plant, may yield larger profits than, say, a 2½ per cent. sulphide ore with, say, same size lode, as in the former case the concentrates produced will go about 80 per cent. copper, and in the latter 8 to 15 per cent. copper. The costs to place the sulphide concentrates into refined copper will be much greater than in the case of the metallic concentrates.

"A sulphide ore, low in copper and high in sulphide of iron, and carrying a sufficient percentage of free silica (in sulphide smelting, analysis may show that there is a certain percentage of silica; but it is necessary to determine if the silica is free or combined; if combined, it is no use for pyrite smelting), with a reasonable freight rate for coke, can be worked at a very low cost; but if the ore is deficient in free silica, and free silica has to be added in, say, the form of quartz, it means an increased cost to smelt the ore, also reducing the capacity of the furnace, with the result that working costs are higher.

"On low grade propositions, unless there is a body of sufficient size, or of small size and great length, so that a number of machine drills can be kept going to keep a large treatment plant running constantly, it is madness to attempt to work the property. The cost of management and staff over a small plant is about the same as over a large one. Take a concentrating mill that treats, say, 100 tons in twenty-four hours. Now, if that mill is enlarged to treat 300 tons per twenty-four hours, the number of men employed about the plant will be very slightly increased, and the only other increase will be the extra cost for fuel and renewals, which is a small item over the whole. The same applies to furnace treatment.

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"Taking, say, the same district and about the same conditions, the higher the grade of the ore the less it must cost to produce a ton of copper. To mine 12 per cent. ore would cost no more than to mine 3 per cent. ore; but the mine with the 3 per cent. ore has to mine 4 tons to obtain the same tonnage of copper—in fact, would have to mine 4½ tons, as the loss in treatment would in the latter case be proportionately greater. So, to produce a ton of copper from a low-grade property, there must be increased cost.

"One may have a large lode of low-grade ore; but there is a limit to the grade that can be worked at a profit, and one of the great factors is the cost to mine same. No matter how wide the lode may be, once the ore is won the lode must be made secure by filling with mullock or timbering; and in undertaking to make a profit on low-grade ore one must consider what it is going to cost to mine, also to know in what state the copper in the ore is in, and what grade of copper it will produce in the first treatment operation, as the higher the grade produced the less after-cost to place it into refined copper.

"Where suitable fluxes carrying gold and silver can be purchased, such fluxes may perhaps make a low-grade non-paying copper property a financial success, as buyers of marketable copper will pay a high price for gold and silver contents, as the process to extract the gold and silver increases the quality of the copper, resulting in a higher price per ton of copper being obtained.

"If possible, never produce a matte for sale. Go a step further, and make marketable copper. There is always a market for the latter; but there are few buyers for an unfinished product, with the result, if you produce a matte, you are in the hands of a few.

"Capital is found to part-open up a mine and erect treatment works; but the two most important items for copper-mining are fuel and stores, and unless extra capital in the first instance had been allowed for to instal a system of transport, it may make all the difference between profit and loss on a low-grade property.

"In the erection of copper-treatment works, it is a good maxim not to erect until the sulphide zone is reached and opened up (in the case of a bedded deposit in limestone there may not be sulphide ore). To treat only oxidised ores there is bound to be high losses of copper in slag, and once the oxide ore is worked out, and it comes to working up the sulphide ore, the oxidised ores, which in smelting would have most valuable in bringing up quickly and cheaply the grade of the copper in the matte, are no longer available. Again, by knowing the character of sulphide ores obtainable, one is in a better position to judge as to the most suitable plant, and to a great extent as to the permanency of the mine, and if the property will warrant an outlay on a large plant."

Smelting.

Nothing racks to pieces a furnace of this description (reverberatory) as cooling it down occasionally, owing to shortage of ore or fuel, or other similar causes, which are usually the want of foresight.[1]

Hence the wisdom of accumulating ore and fuel stocks before commencing smelting. Frequently this policy is neglected, the furnace being

[1] Peters' Principles of Copper Smelting, 1907, p. 508.

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started before adequate proving and accumulation; and wor
pecting of lower levels as frequently ceases whilst the furnace
erected.

*Furnace Temperatures, judged by appearance of fire and by fusion
metals.*—(H. M. Howe.)

Red—just visible	475	deg.	Cent.,	887	deg. Fah.
,, dull	550	,,		1,022	,,
,, cherry—dull	625	,,		1,157	,,
,, ,, full	1,165	,,		2,129	,,
,, light	850	,,		1,562	,,
Yellow—full	1,000	,,		1,832	,,
,, light	1,050	,,		1,922	,,
White	1,150	,,		2,102	,,

Melting Points of Metals.

Tin	232	deg.	Cent.,	449·6	deg. Fah.
Bismuth	260	,,		500	,,
Lead	326	,,		618·8	,,
Zinc	420	,,		788	,,
Antimony	632	,,		1,169·6	,,
Aluminium	655	,,		1,211	,,
Silver	960	,,		1,760	,,
Gold	1,065	,,		1,949	,,
Copper	1,080·5	,,		1,976	,,
Nickel	1,500	,,		2,732	,,
Platinum	1,780	,,		3,236	,,

Furnace Products.

"Blue metal"	Matte containing 60 to 70 per cent. of coppe
"White metal"	,, ,, 70 to 75 ,, ,,
"Pimple metal"	,, ,, 80 to 85 ,, ,,
"Black Copper"	Impure metallic copper; name derived fro tion of surface to dull black.
"Blister Copper"	Highest grade of unrefined metal, 96 to cent. copper; name derived from blebs o ters," in which gases are retained as it ha

Market Brands.

English	"Best Selected."
	"Tough Copper."
	"Tile" (brittle for castings).
	"G.M.B." (good merchantable brand).
	"Chili Bars"—blister, refined before use.
	"Electrolytic."
American	"Lake," from Lake Superior native copper.
	"Electrolytic," by electrolysis of blister.
	"Standard" (not very good or bad).
	"Casting."

Smelting Deductions.

The old Swansea smelters' practice of demanding 21 cwt. to the to
copper ore, perpetuated in some local Customs smelting plants, is
gether inequitable in regard to the producer. So far as the Write
aware, it is applied only to copper ores.

The unreasonableness of the exaction is more apparent where l
quantities are dealt with, especially when contingent costs are high,
miner being mulct, not only in the product of his mine, but in ac
cash for mining and transport.

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The following statement, based on actual facts, should make this clear :—

100 tons, less 100 cwt. = 95 tons.

	£	s.	d.
Value of deduction—5 tons—28 per cent. ore at £97 per ton of copper[1]	135	16	0
Cost of mining and dressing, at 10s. per ton	2	10	0
Carriage from mine to smelter	17	11	3

	£	s.	d.	£	s.	d.
Less smelting charge 5 tons of ore at £2 6s. 6d. per ton	11	12	6			
„ 1½ units deducted from 5 tons of 28 per cent. ore	7	5	5			
„ 1s. 9d. per unit „ „ „ „	12	5	0			
				31	2	11
				£124	14	4
Add 14s. allowance due on first-class ore				0	14	0
Net value of deduction against miner				£125	8	4

This deduction is over and above all legitimate treatment charges and all reasonable smelting-loss margins, 1½ per cent. being deducted from the metallic contents, as well as 1s. 9d. per unit from market value.

The margin for smelting loss is sufficiently high; indeed, slags approaching 1½ per cent. in copper would certainly be regarded as slovenly work, and inexcusable. This fact is thrown into strong relief by contemplation of what such a loss would mean to enterprises like the Great Cobar (Limited) and Lloyd Copper Company (Limited), with their 2 to 3 per cent. propositions.

"Unfortunately, it is the small producer, who has not sufficient ore in sight or capital to establish reduction works, who is thus penalised.

"How the deduction is viewed in England and America may be judged from the following extracts :—

"Nichol Brown and C. C. Turnbull write: 'For some reason or other the custom of delivering a baker's dozen in really thirteen, or the long hundred, really 120, which prevailed in many trades during mediæval times, but since in most cases been discontinued, lingered on and is still very common in the delivery of ore. In the case of copper ore, the recognised addition was at the rate of 1 in 20; so that for every ton bought, 21 cwt. were delivered, an advantage to the smelter of 5 per cent. in weight. Over and above this, an allowance for draftage was made of 3½ lb. in every 3 cwt. bought, which meant that 24½ lb. were allowed from a ton of 21 cwt. This was an advantage of another 1 per cent. to the smelter; so that, in all, he was allowed 6 per cent. increase in weight on every ton of ore delivered at his works.'[2]

"America has a simpler and more equitable method. Ore weighed and delivered in the usual way, no allowance being made on the actual beam and scale weight, a first allowance, 1·3 per cent. being made for loss in smelting, whether high or low grade ore."[3]

"Peters writes: 'The smelters' ton of 2,352 lb. is a local and, I believe, nearly obsolete measure of weight.'

"It may be found in some of the older mining and metallurgical literature of England, and is said to have originated from a very natural desire on the part of the smelters to protect themselves against losses when purchasing ore, by insisting that they should receive an extra hundredweight (112 lb.) for good measure with each ton (2,240 lb.) of ore.

[1] Value of copper at the time (1907). The proportions remain constant whatever the price of the metal.
[2] A Century of Copper, 1900, p. 70. [3] *Ibid.*, p. 72.

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"This precaution, taken in conjunction with the 'dry assay' of copper (to be described later), would seem admirably adapted to safeguard them against metallurgical losses. The system has never flourished in the United States."[1]

"*Wet assay* of an ore, or product, means the actual amount of copper which it contains, as determined by accurate chemical methods, and expressed in percentage.

"The '*dry assay*' means (in the United States) the wet assay minus some agreed arbitrary deduction. This arbitrary deduction is a quantity established by local custom, and is often the number 1·3." (1·3 deduction from wet assay of ore; thus 13·6 — 1·3 = 12·3 per cent. of copper.)

"This arbitrary deduction from the true assay of copper ores is derived from the former practice at Swansea of making the copper assay of the parcels of ore offered for sale by means of a fire method, by which the ore was melted, and the resulting matte was refined, in a manner analogous to that pursued in the actual smelting process.

"This Cornish fire assay was supposed to yield results approximating those which were obtained in the actual smelting of the ore on a large scale, and thus to cover the actual metallurgical losses.

"It answered very well when executed by assayers thoroughly versed in this peculiar and difficult operation, and when the ores were tolerably uniform in composition; but is not suited to the broader commercial conditions, and is too susceptible to the personal equation.

"It would, no doubt, have been better in the United States to drop all attempts to provide for metallurgical losses in the original assay of the ore, and to add merely a sufficient sum to the smelting price to cover this point. But it is difficult to overthrow established customs, and a compromise was made by which the content in copper is determined by accurate chemical methods, and a deduction of 1·3 (or some understood amount) is made therefrom, the resulting figure being called the *dry assay*, and representing the amount of copper for which the miner is paid."[2]

Brief Description of the Great Cobar (Limited) Electrolytic Plant at Lithgow, and the Process of Refining.

(By G. H. Blakemore, General Manager.)

"The electrolytic plant consists of seven depositing dynamos, six of which are four-pole dynamos of 72 k.w., voltage being 60, and the amperage 1,200; the other dynamo being 15 k.w. capacity, voltage 25, and amperage 600. The six large dynamos are driven by six compound tandem steam engines, and one single-cylinder engine drives the small dynamo. In the engine-room are three Knowles' air-pumps, for forcing air through the electrolyte in the depositing tanks, and for providing air to the air-lifts, which elevate the electrolyte to the distributing tanks above the depositing tanks. The depositing tanks are at present arranged so that five of the large dynamos do the work of deposition, leaving one standing idle.

"Two dynamos are working 144 tanks each, whilst the other three dynamos each have 128 depositing tanks.

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[1] Principles of Copper Smelting, 1907, p. 556. [2] *Ibid.*, pp. 558–559.

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"The small dynamo of 15 k.w. capacity is used for removing excess copper in the electrolyte and for providing electricity for the Doré parting plant.

"The plan herewith fully explains the system of the arrangement of the tanks:—

"The tanks are made from Oregon pine. The boards are 2 inches thick, and dressed on both sides; they are lined with 6 lb. lead, the lead being carried over the top edges of the tanks, so as to protect the wood from the acid liquor. To protect the lead lining from injury, a lining of 1 inch redwood is fitted. All woodwork about the tanks is boiled in paraffine wax of a melting point of 140° F. for half an hour. No pitch or bitumen is used in the construction of the tanks. The electrolyte flows from one tank to the next below it through leaden pipes, which are burnt on to the lead lining, and pass through the wooden end wall of the tank. On this lead pipe is fitted a short piece of rubber pipe carrying a glass pipe, 5 or 6 inches long, which is long enough to convey the electrolyte into the next tank. The tanks of each dynamo are arranged in four long rows. Each row has three terraces, and each terrace a separate feed of electrolyte; and the tanks in each terrace are stepped 3 inches below one another, so as to ensure a proper circulation of the electrolyte from tank to tank. At the end of a terrace of tanks the electrolyte escapes to the collecting sump, from where it is elevated by an air-jet into the storage tanks, and thence into circulation again.

"By providing three separate supplies of electrolyte to every row, in the manner described, a fairly even temperature is maintained in the electrolyte.

"The electrolyte is warmed to 120° to 125° F. by means of steam passing through hard lead coils. The effect of temperature on the electrolyte is to make the cathodes grow smoothly, and it also obviates a risk of short-circuiting to which rough cathodes are liable, and it further reduces the resistance of the electrolyte, enabling more copper to be produced for the same horse-power.

"The average composition of the electrolyte is about 13 per cent. of bluestone, 13 per cent. free H_2SO_4; specific gravity, 1·16 to 1·18 at the inlet. In the course of the passage of the electrolyte through a series of tanks, it increases in bluestone.

"For instance, the analysis of the inlet liquor will be, say, 12·8 per cent. free acid, 13·8 per cent. bluestone; and the outlet liquor from this will assay 12·5 per cent. free acid, 14 per cent. bluestone.

"The electrolyte which passes through the tanks of the small dynamo by which copper is being removed from the electrolyte, and where insoluble anodes are used, will assay as follows:—

"Inlet, 12·4 per cent. free acid, 13·6 per cent. bluestone; outlet, 15 per cent. free acid, 8·4 per cent. bluestone. These figures are not at all fixed. There are constant variations from day to day in the composition of the electrolyte; but the analyses given are an index to the character of the electrolyte from the depositing tank and from the insoluble anode tank. If the excess copper were not removed by electrolysis, then it would have to be taken out by crystallisation, otherwise the amount of bluestone would reach such a point in the electrolyte that it would commence to crystallise out in the tanks, and at once bring about short-circuit of a dangerous character. Each tank is separately aerated by a small jet of air working at the bottom of a leaden pipe, which hangs in the liquor;

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the air-jet forces up electrolyte from the bottom of the tank, and aerates the liquor, while at the same time it brings up from the bottom of the tank the denser liquor which is constantly being formed by the process of electrolysis. This creates a circulation of the electrolyte apart from the flow of the electrolyte from one tank to the other. If there were no air-jet working in each tank, the tendency of the liquor is to divide itself into two layers, the lower layer rich in bluestone, the top one in free H_2SO_4. The consequences of this are: first, crystallisation of bluestone at the bottom of the tank, and second, cutting through of the anodes and cathodes at the junction line of the two layers of liquor. Air agitation tends also to oxidise some of the impurities which otherwise accumulate in the electrolyte.

"If the temperature of the electrolyte is 120° F. on entering the top tank of a terrace of tanks, it will probably have fallen to 90° by the time it leaves the tenth tank of the terrace, owing to the cooling effect of the atmosphere. If the liquor could be maintained at 120° in every tank, better working results would be obtained. With an electrolyte containing 12 to 14 per cent. of free acid, a temperature of 90° to 120° is imperative—preferably 120° if it can be obtained—because with a lower temperature an electrolyte so high in acid as 12 per cent. or 14 per cent. causes the copper to be deposited on the cathodes in fine wires instead of a level growth; and as these wires grow fast, they cause in an hour or two numberless short-circuits in every tank. It is advisable to work with a high acid percentage, first, to reduce the resistance of the electrolyte, and secondly, because the quality of the copper is superior to that deposited in an electrolyte low in acid.

"The amperage per square foot of cathode surface is about 14; the voltage per tank is about 0·3 volts. There are nine anodes and nine cathodes per tank; the square feet of area on a cathode is about 10 feet, and the amperage of the dynamo is from 1,200 to 1,300 ampères. In cold weather the dynamos can be run up to 1,300—perhaps 1,400—ampères without danger, if the resistance or voltage is low enough to allow of it being done.

"The copper treated in the electrolytic plant is first refined before it is cast into anodes. The anodes assay about 99·4 per cent. copper before being electrolytically treated; the silver contents are from 16 to 20 oz., and the gold from 2 to 4 oz. Each anode weighs approximately 200 lb. These are put into the depositing tanks as required. The whole of the anodes are not removed in one lot, as is done in many American refineries. An anode generally cuts out in three weeks' time. The remains of it is then taken out, washed from gold and silver mud, and sent to the furnace to be remelted up into anodes; but as this copper has once been charged to the electrolytic plant (as a book-keeping point), these anodes are now described as 'scrap anodes,' to distinguish them from the anodes made direct from the matte. The weight of scrap anodes made is about 8 per cent. of the weight of the original anodes put into the electrolytic tanks.

"The cathodes are removed in regular numbers every day from each set of tanks on a dynamo, but not in regular numbers from every tank. They are only removed when they have grown to such a size as to render short-circuiting possible. The removal of the cathodes is so arranged that all the cathodes are taken out of every dynamo every fourteen days. By working the tanks on this system—that is, leaving in the anodes twenty-one days and the cathodes fourteen days—the short-circuits in the tanks are very materially reduced.

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Depositing Tanks, Great Cobar (Limited) Electrolytic Plant, Lithgow.

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"The cathodes are melted up in weights of 10 to 16 tons into ingots, bearing the brand 'E.L.C., Aust.' The conductivity of this electrolytic copper, measured by Dr. Matthiessen's standard, very often runs over 101 per cent., and never lower than 99½ per cent. The gold contents of the 'E.L.C.' copper rarely exceeds 12 grains, and the silver about 9 dwt. per ton, and the copper contents 99·98 per cent. Each day's charge is separately tested for its conductivity and the gold and silver contents.

"The starting-sheets on which the cathode copper is deposited are grown in the works. First of all, some copper is rolled into sheets about one-eighth of an inch thick; these are cut to the size required, which is about 1 inch wider and 3 inches longer than the starting-sheet will be when grown. These rolled-copper sheets are dipped in boiling tallow, allowed to drain and cool, and are then dusted with ground graphite. The bottom edge and two side edges are then dipped in molten tallow once more, to form an insulated rim on the rolled plate. These prepared sheets are then hung in the depositing tanks, and copper is deposited on the graphite surface from the ordinary auriferous anode; but where the edges have been dipped in tallow no copper deposits. The rolled sheets are left in the depositing tanks from two to four days. They are then withdrawn, and the two thin sheets of copper which have deposited, one each side of the rolled plate, are then stripped off by boys. The rolled sheets are once more dipped in boiling tallow, dusted with graphite, &c., and put back into the depositing tanks to grow more starting-sheets, whilst the very thin starting-sheets are hung in other depositing tanks as a cathode, and in two weeks' time are heavy enough to send to the cathode furnace to melt up into 'E.L.C.' copper ingots.

"The dynamo which is removing the excess copper from the electrolyte has but twelve tanks on it. While the resistance on the depositing tanks working with soluble copper anodes is but 0·30 volts, in these tanks, using an insoluble lead anode made from 8 lb. lead, the resistance sometimes reaches 2 volts per tank. The copper removed in this way is about 60 tons per annum, being deposited very much more slowly than is the case in the tanks using soluble copper anodes, and the face of the cathode produced is quite polished. This copper is very tough, and is particularly good copper.

"The mud which accumulates in the ordinary depositing tanks, where the anodes are being treated, contains copper, selenium, tellurium, iron, gold, silver, &c. It is taken out of the depositing tanks at regular intervals and sieved through copper sieves, to remove the large pieces of copper that have fallen off the anodes. It is then dried, afterwards heated to redness, to burn off any grease and to alter the graphite. This simple point of heating the mud redhot enables all the copper to be dissolved out by the sulphuric acid of 1·830 with which it is next boiled. The boiled mud is then fused with a little sand and carbonate of soda to a Doré bullion, which is cast into 7 or 8 lb. anodes, and refined in a small Moebius plant for the separation of gold and silver. The gold powder, which is black, is warmed with nitric acid to take out as much silver as possible, and then melted into bars, which are about 980 fine, and sold to the Mint. The silver is melted into 500-oz. bars of 996 to 999 fine, and shipped.

"The composition of the electrolyte in the Moebius tank is as follows:—

"1·7 per cent. copper; 6 to 9 oz. silver per gallon; free nitric, 0·11 per cent. to 3 per cent.; specific gravity, 1·120 to 1·135.

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"The flow of the electrolyte through the depositing tanks is about 1½ gallon per minute.

"The starting-sheets were at one time grown in non-circulating tanks—that is, each tank was separately supplied with electrolyte. The trouble with this arrangement was that each tank was a separate electrolytic refinery, and the quality of the skins or starting-sheets was very irregular and uncertain. A starting-sheet needs to be tough; but in the old system it was not at all uncommon, out of thirty-six tanks growing skins or starting-sheets on the still-liquid principle, to not get more than 5 per cent. of the total skins produced fit for use as cathodes. As some hundreds of skins are required daily, this brought about a serious shortage of the necessary starting-sheets or skins, and had to be remedied, or else a dynamo or more would have to stop for want of them. Using some colloidal substance like gum was the usual remedy; it acted sometimes, and at others failed. A great deal of labour was entailed by the system, and a considerable amount of dissatisfaction always resulted from it. Now the skins are grown in the ordinary circulating liquor, and the usable skins or starting-skins represent 95 per cent. of the total produced.

"The depositing tanks rest on six glass blocks. The copper bars carrying the current are made on the works, and give about 2¼ square inches in section for a current up to 1,400 ampères. The copper leads are insulated from the tanks, and the tanks are insulated from the earth and from each other. The anodes are made with one arm long enough to rest on the positive lead; the other arm is shorter, and rests on a glass block standing on the wall of the tank.

"The efficiency of the depositing tank is now over 90 per cent. of the power indicated on the volt and ammeters. The capacity of the five sets of tanks is about 140 tons of electrolytic copper per week.

"Scrap-holders were at one time used in the depositing tanks to work up the scrap anodes in the course of electrolysis. They were made of lead in basket form, pierced with holes, and rested by means of copper pipes on the positive lead. The electrolyte circulated through them. Experiment showed it took two or three times as long to redeposit the copper from the scrap holders, and, counting interest and the cost of cutting up the scrap and resistance losses, it was cheaper and more expeditious to remelt the scrap and recast the copper into anodes.

"The conductivity apparatus used is that made by Elliott Brothers, of the Century Works, Lewisham, London.

"It consists of a Wheatstone bridge, with fixed ratio arms and a copper coil standard equivalent to a pure annealed copper wire 100 inches long and weighing 100 grains of 100 per cent. conductivity according to Matthiessen's standard—that is, ·1516 British Association ohms at 60° F. The conductivity is arrived at by the formula—

$$\frac{L^2}{W}$$

where "L" is length in inches, and "W" is weight of the wire in grains; or,

$$\frac{0{\cdot}1516 \times L^2}{W{\cdot}R}$$

0·1516 = Resistance of 100 inches of pure annealed copper wire at 60° F.
L = Length of test in inches.
W = Weight in grains.
R = Resistance in B.A. ohms at 60° F.

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"R. is adjusted until it is equal to standard of pure annealed copper wire by altering its length until the galvonometer in the apparatus shows no deflection.

"The annealing of the sample of wire is done by covering it with sawdust on an iron plate, which is put over a fire until the sawdust takes fire, when it is allowed to smoulder away. When cool, the wire is cleaned. It is drawn through about a 23 B.W.G.-size hole."

Mineral Associates of Copper Ores injuriously affecting Smelting Operations or the Quality of Copper.

The presence of sulphides of zinc and lead, especially the former, add greatly to the troubles of the smelter, owing to their tendency to choke the furnace by forming a crust in the throat, necessitating frequent "barring-down." The effect of zinc sulphide (blende) in copper-smelting is stated by Sticht, in "Peters' Modern Copper Smelting,"[1] to be that part only is oxidised, and enters the slag to that extent; it is also deposited in the furnace throat. "A greater portion of it in its unaltered chemical state is held in solution in the slag chemically or merely mechanically. Another portion enters the matte, and the balance escapes as fumes, part of which is sublimated and regenerated in the upper and cooler regions of the furnace-shaft. Its immediate action is to vitiate the separation of the matte and slag by decreasing the specific gravity of the former."

Another authority quoted—Herbert Lang—in the same work[2] refers to the influence of zinc-blende on smelting operations, as follows:—"Zinc enters the slag as oxide and the matte as sulphide, rendering the former viscid, the latter light, and by injuring the separation diminishes very seriously the saving of the precious metals. By volatilisation as metal or oxide it causes heavy loss of silver."

At Lake George Mines, Captain's Flat, zinc entered the slag to the extent of 14 or 15 per cent., and into the matte from 9 to 10 per cent.

Dr. Schnabel states that large quantities of zinc form with the slag and a portion of the matte—a porous mass, called *skumnas* (scum or foam) in Sweden—from which the copper can only be extracted with great difficulty. He advises the conversion of zinc sulphide as far as possible into oxide during roasting, carbonaceous matter being mixed with the ore during calcination to decompose any basic sulphate formed during the operation.[3]

The principal copper mines of the State, so far, have been fortunately free from serious zinc troubles. A thin skin of zinc-blende occasionally coats either wall of the Cobar lode; but the quantity is so slight compared with the mass of the ore that it can be disregarded. At Peelwood it was unpleasantly prominent in the lowest workings; at Apsley, Wiseman's Creek, and Captain's Flat mines it is intimately associated with the copper sulphide.

The recently-discovered Ettrema lodes in the Nowra division, and the Just-in-Time in the Casino, consist principally of zinc sulphide, associated in parts with chalcopyrite, and in the first-mentioned with mispickel also.

In both the admixture of the chalcopyrite with the zinc-blende is so intimate as to defy classification by hand, whilst equal densities prevent gravity separation, though the latter would, to a certain extent, be effective in the case of the heavier mispickel.

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[1] 7th edition, p. 424. [2] *Op. cit.*, 1896, p. 79.
[3] Handbook of Metallurgy. Trans. by H. Louis. Vol. I, p. 89.

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To render the chalcopyrite marketable or smeltable, magnetic separation would be necessary.

The amount of zinc that may be introduced into the furnaces depends largely upon surrounding conditions; but it is noteworthy that in Customs Smelting Works any excess of zinc over 10 per cent. (in some instances 5 per cent.) carries a deduction of 1s. per unit. To quote the tariff of the Walleroo Smelting Company of South Australia: "In no case will any zinc be paid for, and for all zinc over 10 per cent. a deduction will be made at the rate of 1s. per unit." The rates quoted for copper ores in the tariff issued by the Great Cobar, Limited, in connection with its Lithgow Refining Works, are stated to be for copper ores free from impurities. The smelting charges for ores containing arsenic, antimony, tin, zinc, bismuth, &c., are higher than the ordinary, and vary proportionately with the nature and quantity of the impurities present. Whilst smelting companies reserve the right of rejection altogether.

The effect of zinc entering the matte as sulphide, in copper-smelting, must be to seriously diminish realisation values of such material, as its deleterious effects manifest themselves in refining.

The effect of metallic zinc on copper is variously stated by the following authorities:—

Bruno Kerl states[1] that "0·6 per cent. of zinc produces red-shortness, to a degree cold-shortness, whilst many alloys of copper with zinc (malleable brass) are malleable between certain limits of temperature."

C. Schnabel[2] states "that zinc alloys itself with copper and diminishes the malleability of the metal when hot. A copper-zinc alloy, with more than 20 per cent. of zinc, is at all temperatures less malleable than copper."[3]

C. Stölzel[4] states that copper containing 0·6 per cent. of zinc and 0·25 per cent. of tin causes the metal when beaten out under the hammer to show fractured (rugged) edges.

E. D. Peters states that zinc forms an alloy with copper in every proportion, and slightly lowers its ductility at high temperatures, but until it reaches at least 18 per cent., the tenacity of the alloy at ordinary temperatures does not seem to be lessened.[5]

Bismuth, however, is the most injurious impurity in copper, as very small quantities render the copper unworkable. Dr. Peters states that "it clings to copper with much tenacity, and affects its properties in a most surprising manner."[6] Hampe, quoted by both Dr. Peters and Dr. C. Schnabel, of Clausthal,[7] states that copper containing as little as 0·02 per cent. of bismuth is red-short, and 0·05 cold-short, the term "red-short" signifying brittleness when red-hot, and "cold-short" brittleness when cold. The same authority also states that with 0·1 per cent. of bismuth copper crumbles under the hammer at red heat, and that the tendency to cold-shortness is somewhat counteracted by the presence of a certain proportion of antimony. Schnabel and Louis state[8] that oxide of bismuth, which is mechanically taken up by copper, affects it like the metal, but in a less degree as far as cold-shortness is concerned, its effect being further diminished if the bismuth oxide is combined with cuprous oxide.

Bismuth is present in the Great Cobar lode to a small extent. In a series of analyses by Mr. W. A. Dixon, F.C.S., F.I.C., of the oxidised ores worked in 1878, bismuth was found to be present in proportions ranging from 0·21

[1] Grundriss der Metallhüttenkunde, 1881, p. 230. [2] Handbuch der Metallhüttenkunde, 1894, Vol. I, p. 3.
[3] *Op. cit.* Trans. by H. Louis, 1898, I, p. 3. [4] Die Metallurgie, Vol. I, 618, 1886.
[5] Mod. Copper-Smelting, 9th ed., 1898, p. 2. [6] *Ibid.*, p. 2.
[7] *Op. cit.* Trans. by H. Louis, 1898, I, p. 3. [8] *Ibid.*, p. 4.

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to 2·58 per cent.[1] The same authority analysed the copper from these ores in 1879,[2] which he described as somewhat difficult to refine, and not coming to the proper "tough pitch," owing to the presence of bismuth. Following are the results obtained :—

Copper	99·346	
Bismuth	·419	
Iron	·083	
Lead	·086	
Silver	·026 = 8 oz. per ton.	
Antimony	·029	
Traces of arsenic, nickel, cobalt, gold, and loss	·011	
	100·000	

As the Cobar copper is now electrolytically refined, all impurities are practically eliminated, as will be seen in the analysis of the metal under the heading of Great Cobar.

Arsenic, usually in the form of mispickel, is one of the commonest and most objectionable associates of copper ores. Arsenic, and also antimony, though volatile, readily combine with the metallic bases, forming combinations difficult to split up. This affinity necessitates keeping the metal in the copper refinery at a high temperature for an excessive period to allow for volatilisation, a process involving great destruction to the furnace linings. The removal of arsenic is assisted by the addition of pyrites during calcination, which volatilises a portion as sulphide of arsenic.[3] At Sunny Corner realgar and orpiment (sulphides of arsenic), by their bright red and yellow colours, sometimes characterised the roasted ore.

Dr. Peters states that arsenic has a greater affinity for metallic copper than for matte; hence, if the smelting charge be so regulated that there shall be an insufficiency of sulphur to combine with the copper, the product of a quick fusion will be a considerable quantity of rich matte comparatively free from arsenic and a much smaller quantity of very impure metallic copper known as "metallic bottoms."[4]

The effect of arsenic on copper was formerly regarded as highly injurious, even $\frac{1}{10\cdot0}$ of arsenic producing both red and cold shortness, but Schnabel[5] quotes Hampe[6] to the effect that 0·5 per cent. of arsenic produces no bad effects; only when the proportion rose to 1 per cent. could a slight degree of red-shortness, but no cold-shortness, be detected. According to the same authority, copper with 0·8 per cent. of arsenic could be drawn into the very finest wire, and small percentages of arsenic (0·216 per cent.) even increase the tenacity of copper.[7] According to Stahl, a small amount of arsenic prevents copper from becoming porous.

Professor W. C. Roberts-Austen[8] states that arsenic materially increases the electrical resistance of copper; on the other hand, it increases its durability when used in locomotive fire-boxes.

Tin, according to Dr. Peters, alloys with copper in all proportions and begins to injure its ductility when present in quantities of 1 per cent.

Nickel, frequent in commercial copper, up to 0·3 per cent. seems to produce no injurious results.

Dr. Peters states that iron when present in the usual minute proportion probably has no appreciable effect on the useful qualities of copper—except possibly its electrical conductivity.

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[1] Ann. Rept. Dept. Mines for 1878, pp. 38–41. [2] *Ibid.*, 1879, p. 29.
[3] Handbook of Metallurgy, I, p. 25, 1894. [4] Mod. Copper Smelting, 5th ed., 1892, p. 329.
[5] *Op. cit.*, 1896, I, p. 4.
[6] Chemiker-Ztg., 1892, 16, No. 42. [7] Inaugural Dissertation. Turbingen, 1896.
[8] An Introduction to the Study of Metallurgy, 1894, p. 11.

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The action of lead on copper is stated by Schnabel, on the authority of Hampe's recent experiments, to be that 0·15 per cent. does not affect the malleability of copper in any way; with 0·3 per cent. of lead it becomes slightly red-short, and with 0·4 per cent. slightly cold-short. With 1 per cent. of lead copper is unworkable.

Dr. Peters states while lead is a useful addition to copper to be employed for certain mechanical purposes, and assisting in procuring solid castings, it has a decidedly injurious effect if present in too large quantities. One-third of 1 per cent. is sufficient to make the metal both red-short and cold-short; while 0·75 per cent. will ruin copper for any ordinary purpose.[1]

Antimony in small quantity, according to the same authority, does not affect the good qualities of copper. With 0·529 per cent. copper can be drawn into the finest wire equally as well as pure copper. One per cent. of antimony, however, renders copper extremely red-short. It likewise impairs its electrical conductivity.

Hampe's latest experiments[2] show that silicon (the metallic base of quartz) hardens copper without impairing its toughness or its malleability when less than 3 per cent. is present. With 6 per cent. of silicon copper becomes brittle; with 8 per cent. it is readily pulverised, and with 11·7 per cent. it is as brittle as glass. The electrical conductivity of copper is impaired by small proportions (0·52 per cent.) of silicon.

Sulphur in quantities of 0·25 per cent. lowers the malleability of copper. 0·5 per cent. produces cold-shortness, though such copper is not red short.[3]

Phosphorus in small quantities seems to produce no injurious effect. At 0·4 per cent. red-shortness is developed (Peters).[4]

The process of copper-refining depends upon the rapid oxidation of the impurities usually associated with copper, and their greater affinity for oxygen; the less oxidisable impurities, however, by the protracted "roast' required for their elimination cause great destruction to the furnace hearths. According to Dr. Peters[5] a considerable part of the injurious substances can be extracted by exposing the pigs of matte to a slow oxidising fusion, the operation being interrupted as soon as a certain amount of metallic copper is formed when the furnace is tapped; the small quantity of copper thus produced contains not only the greater part of such impurities as arsenic, antimony, tellurium, tin, &c., but also the gold-contents. The great affinity of gold for metallic copper and its unoxidisability renders it possible to concentrate it, and, owing to the latter quality it would be theoretically possible to oxidise and slag off the copper, leaving the precious metal behind.

Concentration.

In connection with the lower levels of copper mines in which copper and iron sulphides are leanly distributed through the lodestuff, a prevalent hope is indulged by prospectors that increasing depth will reveal increasing solidity or concentration of these minerals. Certainly instances are not wanting of such a desideratum, but their rarity and transiency but emphasise the necessity for resolutely facing the problem of concentration, for the hope of richer ore-bodies with depth vanishes in the light of experience. Below the water-level gradual depreciation is invariably associated with depth.

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[1] Mod. Copper Smelting, 9th ed. 1898, p. 2. (Schnabel and Louis, I, 1898, p. 5.)
[2] Chemiker-Ztg., 1892, 16, No. 42.
[3] Peters, *ibid.*
[4] *Ibid.*
[5] Mod. Copper Smelting, 5th ed., 1892, p. 378.

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Concentration of lean ores is a question looming large in the future of copper-mining in New South Wales, as the grade of the available ores in the principal producers is low and falling, necessitating increasing outputs to maintain returns. In fact, an optimistic view of the industry is not possible, though discovery may at any time change its aspect. The rich ores of the important mines have been exhausted, and no later discoveries of equal magnitude and richness stand ready for development. Great Cobar and Nymagee, thanks to the kindly nature of their ore, are amenable to furnace concentration. The absence of permanent water supply in the far western copper-fields increases the difficulties to be overcome, which in themselves are sufficient to tax the ingenuity and skill of the most experienced manipulators.

Concentration on a primitive scale was adopted at a few western mines. The "seconds" from the jigs consist chiefly of fragments of earthy and silicious carbonates in slate and fine-grained sandstone, the difference between the gravity of this class of ore and of the waste being so slight as to defy mechanical separation beyond a certain unsatisfactory point. In connection with the "seconds" at Girilambone, the Writer, in 1898, gave some attention to the possibility of mechanically separating the particles after careful sizing, but the difference between the specific gravities of even the richest ore-particles (azurite) and the waste was so slight—0·73—as to render mechanical separation impossible. The green carbonate particles, which are also conspicuous in the "seconds," need only a glance to reveal the fact that their copper contents are more apparent than real; the green particles are mostly quartz stained with malachite, the specific gravity of which is about 2·74, and that of the waste 2·72. Even the translucent crystals of azurite (blue carbonate) contain but 31 per cent. of copper instead of the 53·2 per cent. of the pure mineral.

Though no tests were made with the earthy carbonates of the New Mount Hope and Great Central mines, it is probable that to a large extent the same difficulties will be encountered. At Burraga, since the advent of the Lloyd Company, the great bulk of the ore is concentrated. (See under Burraga.)

These considerations open up the question of the possibility of a leaching process with sulphuric acid being adopted, the acid being manufactured in chambers on the spot from the roasting of lump sulphides from lower levels. Unfortunately, in some of the mines mentioned, so far as the pyritic zone has been pierced, the sulphides of both iron and copper are leanly distributed through the matrix, and therefore unsuitable for the purpose without previous concentration. Given sufficient sulphides suitable for producing sulphuric acid, the process is worthy of serious consideration, as a similar means of extraction has been adopted for lean oxidised ores by the Arizona Copper Company, at Clifton, Arizona, U.S.[1] The Girilambone tailings were subsequently profitably leached. (See Girilambone.)

Carbonates and oxides of copper can be dissolved by hydrochloric and sulphuric acids, ferrous chloride, ammoniacal compounds, hyposulphate of soda, and ferrous sulphate; but only the first three have been practically employed. The two first act very energetically.

At the World's Columbian Exhibition, Chicago, 1893, the Writer had the "Douglas Central Flue Revolving Cylinder Furnace" explained by means of a model by the inventor, Mr. James Douglas, President of the Copper Queen Mine, Arizona. In this furnace, which is used in connection with

[1] Mineral Industry, 1898, VI, p. 280, *per* J. Douglas.

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above-mentioned process, instead of the heated gases from the fireplace coming in contact with the ore charge, they are conveyed through the furnace by means of a central flue, and the charge is heated therefrom by radiation. The cylinder is of iron, lined internally with firebrick; the central flue is constructed of tiles kept in position by four tiles locked into the lining, these tiles extending the whole length of the cylinder, divide the ore-chamber into four compartments. The fire required to ignite the charge is contained in a movable furnace on wheels, which can be connected or disconnected at will from the cylinder. The air-draft into the ore compartments is regulated by means of an adjustable register, which closes the front or discharge end of the cylinder.

The internal flue is the main difference between the Douglas and Brückner revolving cylindrical furnace, and perhaps the only one so far as practical working is concerned.

For sulphuric acid manufacture the Douglas furnace offers exceptional advantages, inasmuch as it delivers the gases from the ore uncontaminated with any impurities from the fuel used in firing.

The divisions of the compartments are pierced at intervals with slots or openings, so that the ore can fall from one to the other, and thus increase the agitation.

The capacity of the furnace is about 6 tons per diem, when the ore is liable to sinter, owing to presence of lead or high percentage of copper; and up to 12 tons of pure pyrites. Owing to the inaccessible nature of the ore-chambers, ore liable to sinter at a low heat is unsuitable for treatment.

The speed of revolution varies from one revolution in three minutes to one in ten minutes.

A dust-chamber is a necessary adjunct of this furnace.

The vital question in concentration, however, refers almost solely to the sulphides which constitute the permanent sources of supplies, the oxidised ores at best being but superficial. The estimated copper contents of the sulphides under consideration range from 2 to 4 per cent. in gangues of slate, quartzite, and quartz; in the descriptive records of the individual mines concerned full particulars are given of the methods of concentration adopted. It is noticeable in the slate and sandstone or quartzite country, wherein the lodes are mostly segregations or replacements, that where the ore is more concentrated quartz is a more or less abundant associate. Usually, however, the sulphides are sparingly distributed through the matrix. The most advantageous method of dealing with the ore as it comes to the surface is to carefully select all lumps capable of being dressed by hand to smelting grade, and to deal with these separately by breaking and picking. In silicious lodes, such as Girilambone, Mount Hope, and Burraga, too much care cannot be given to this section, for, to quote a high authority,[1] "When ores are silicious a mere rejection of such pieces of barren quartz or wall rock as have accidentally got among the ore, or first become visible on breaking up the large masses, may have a most beneficial influence on the subsequent fusion. Where the expense of treatment is high, and work is conducted on a large scale, the profits resulting from raising the average contents of the ore even a single per cent. is hardly credible, even aside from the increased fusibility due to the decreased proportion of the silica."

[1] Dr. E. Peters, junr.—Modern Copper Smelting, 5th ed., 1888, p. 54.

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The second step in the process is the rejection of the waste mixed with the ore from the working stopes; after screening, the larger fragments could be broken and sorted by cheap boy or elderly labour; by these means a good proportion of actual waste could be at once discarded. In some instances it is unquestionable that a good deal of such material goes direct to the jigs and adversely affects the results proportionately with the quantity added, both as regards efficiency and capacity. There can be little doubt that the benefits of sorting will outweigh the cost, both directly and indirectly.

The sorted lodestuff, with the screenings and fines from the dressing of the "firsts," should then pass through the breakers to the rolls; the mesh of the trommel screens between the latter and the jigs should be regulated by the character of the ore, a second crushing being preferable to fine crushing in the first instance. Attempting to free all the scattered ore particles at the first crushing would, in the absence of an abundant water supply, increase, instead of reduce, the present loss, owing to the great tendency of some of the gangues to slime. If the seconds from the jigs offer sufficient inducement, then finer crushing and further jigging could follow, though better results would be obtained with buddles and vanners. Both the latter are in extensive use in Montana, United States, where fine crushing and concentration are carried out on a large scale. The Anaconda Company are understood to have adopted buddles wholly for the fines to the exclusion of vanners.

At the point of treatment indicated, it will be a matter for consideration, depending on the assay values of the seconds, whether it will not be more advantageous to waste a proportion of the ore than attempt to save it. This question has considerable weight where low-grade ore is abundant and fluxes scarce.

Theoretically, clean extraction, either mechanical or metallurgical, indicates good work, but the term "good work" is purely relative when commercially considered. However desirable it may appear to obtain clean tailings or slags, the cost of securing them may easily outweigh the advantage.

The form of jig most suitable for any class of ore must be decided entirely by practical test and observation. The Cornish, Handcock, and May Bros. machines are each represented in the State.

Concentration is naturally productive of an accumulation of "fines," which is unsuitable for furnace charging; metallurgists suggest several remedial methods of dealing with it, apart from covering or blinding roast heaps and stalls, if such be in operation, viz., mixing into balls with milk of lime and hydraulic cement, or with clay, or moulding into bricks in an ordinary pug-mill, as the finest material possesses inherent cohesiveness. The use of clay as a binding medium should be avoided, if possible, on account of the introduction of useless and refractory material into the furnace. Silicate of soda (water-glass) has also been tried, but its cost precludes extensive use.

The specific gravities and hardnesses of frequently-associated sulphides are as follow:—

	Specific gravity.	Hardness.
Chalcopyrite	4·1–4·3	3·5–4
Pyrite	4·8–5·2	6–6·5
Pyrrhotite	4·4–4·7	3·5–4·5
Blende	3·9–4·2	3·5–4
Mispickel	6·0–6·4	5·5–6

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The Washoe Plant of the Anaconda Copper-Mining Company.

Extracts from description by L. S. Austin, Houghton, Mich.

Concentration.

"The concentrating plant has a side-hill or terrace location, and adjoins the high-level track and storage bins, from which it draws its supply of ore. It consists of two mills, with a power-house between. Each mill has four sections, so there are eight in all. The capacity of a section may be given at 1,000 tons per day of 24 hours, and it may be estimated that 7·5 sections are constantly running, or that one section is down half of the time for repairs or adjustments. This would give a daily capacity, when the ore supply is sufficient, of 7,500 tons. A maximum output of 8,250 tons, however, has been attained. There is a large power and boiler plant between the two halves of the concentrator building, but much of this installation will be thrown out of use when the company obtains its power by electric installation from the plant of Montana Water E. P. Company, 22 miles distant, and the Missouri River Power Company, near Helena, 75 miles away.

"To supply the eight units, already specified, there are eight storage bins, each of 1,200 tons capacity. These bins have flat bottoms, the ore forming its own slope in them, so that the wear of the bin is slight.

"The following outline describes the flow of the ore through one section of the mill:—

(1.) Hopper-bottomed cars of 50 tons capacity to (2).
(2.) Storage or supply bin of 1,200 tons to (3).
(3.) Shaking feed-trough, having a screen-bottom of 1·25-inch round holes, oversize to (4), undersize to (7).
(4.) Coarse crusher, 12 inches by 24 inches, to (5).
(5.) Two trommels, each 36 inches in diameter by 5 feet long, and having 1·25-inch round holes, oversize to (6), undersize to (7).
(6.) Two crushers, each 5 by 15 inches, to (7).
(7.) Two elevators, having 15-inch belt, buckets 7 by 14 inches, speed per minute, 450 inches, to (8).
(8.) Two trommels, 36 inches in diameter by 6 feet long and having $\frac{7}{8}$-inch round holes, oversize to (9), undersize to (13).
(9.) Two two-compartment Harz jigs on 1·25-inch feed, concentrates to (12), middlings to (16), through (15), (8), and (13), hutch product to (14).
(10.) Four Harz jigs.
(11.) One coarse roll, 42 by 15 inches, 1,147 feet peripheral speed, to (13), through (8).
(12.) Coarse concentrates bin; concentrates to blast-furnace in hopper-bottom cars.
(13.) Two 7-mm. trommels, 36 inches in diameter by 8 feet long, oversize to (10), undersize to (16).
(14.) Twelve two-compartment Evans' jigs on 7-mm. feed, size of screen 24 by 41 inches, concentrates to (32), middlings to (35), hutch product to (32).
(15.) One fine roll, 42 by 15 inches, 1,147 feet peripheral speed, to (16), through (8) and (13).
(16.) Four 5-mm. trommels, 36 inches in diameter by 6 feet long, making twenty revolutions per minute, oversize to (14), undersize to (18).

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[1] Transactions Am. Institute Mining Engineers, 1907, XXXVII, pp. 431–485.

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(17.) Twelve two-compartment Evans' jigs, 5-mm. feed, concentrates to (32), middlings to (35).
(18.) Four 2·5-mm. trommels, 36 inches in diameter by 7·5 feet long, oversize to (17), undersize to (19).
(19.) Twelve 2·5-mm. Evans' jigs, concentrates to (32), middlings to (35).
(20.) One middlings-roll, 42 by 15 inches, to (21).
(21.) Four 1·5 by 12-mm. diagonal-slot trommels, 36 inches in diameter by 6 feet long, oversize to (20), undersize to (22).
(22.) Four three-spigot separators, spigot-product to (23), overflow to (26).
(23.) Eighteen three-compartment middling jigs, 1·5-mm. feed, concentrates to (32), middlings to (24), tailings to dump.
(24.) Three 6-feet Huntington mills, fifty-three revolutions per minute, 62 tons capacity, grinding to pass a 1-by 12-mm. slot-screen, to (25).
(25.) Eighteen three-compartment Huntington mill finishing jigs, 1mm. feed, concentrates to (32), middlings to (24), tailings to dump.
(26.) Sixteen settling-tanks, 5 feet wide by 4 feet deep by 18 feet long, spigot-product to (27), overflow to (28).
(27.) Eighteen Wilfley tables, concentrates to (32), tailings to dump, slime to (29), middlings to (34).
(28.) Slime ponds situated below the reduction works.
(29.) One large tank, spigot-product to one Wilfley table (30), overflow to (28).
(30.) One Wilfley table, concentrates to (32), tailings to dump.
(31.) Elevator to (32).
(32.) Settling-tanks, concentrates to roasting furnaces, overflow to (28).
(33.) Eighteen Wilfley tables, concentrates to (32), tailings to dump, slime to (28).
(34.) Eight tanks, spigot-product to (33), slime to (28).

"It will be noticed, in this scheme of separation, that no product of the coarse jigs is allowed to go to waste, but that all the portion going over the tail-boards of these jigs is recrushed and sized for further jigging. No tailings go to waste larger than 1·5 mm. Screening by trommels is carried as far as practicable, after which the spigot-products of classifiers are used on the fine jigs. Settling-tanks are used for unwatering, and for classifying the unwatered product. All fine concentrates from the fine jigs and from the Wilfley tables pass to an extended series of boxes in which the concentrates settle out, while the supernatant water slowly passes through the boxes, dropping most of its load, the settled product being drawn off at the bottom of the boxes through water-tight gates or valves. The final muddy water, however, is carried half a mile by launders to the slime-ponds, elsewhere described. The coarse concentrates go to a set of hopper-bottom bins, from which they are drawn off to cars, and carried to the storage bins at the blast furnaces.

"The concentrating ore is practically chalcocite, enargite, and pyrite in a quartz and aluminous gangue.

"*Blast Furnace Plant.*

"*Construction.*—At present there are three large-sized furnaces, each 51 feet long, and one furnace 180 in., or 15 feet long. At the slag floor level are seven fore-hearths or settlers, as arranged for the original furnaces, which serve equally well for the enlarged furnaces, there being two fore-hearths for each. A matte-track, at a lower level, serves to bring in the matte-ladles, into which the matte of the fore-hearths is tapped.

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The large blast-furnaces, 56 by 612 in. tuyere-dimensions, have side-boshes of 8 inches, making the width at the throat 6 feet. There is no end-bosh. There are two tiers of jackets, each 7 ft. 5 in. high. In either row, and on either side, the three central jackets are 7 feet wide each, and the four remaining ones are 7 ft. 6 in. each, making thus the total length of 51 feet. The concrete foundation is surmounted by the two original crucibles, to which was added the connecting bridge, the latter formed of water-cooled plates, supported by short jack-screws. The crucibles, or sumps, as they may be aptly called, slope to the tap-hole. The bridge portion has a hearth sloping either way from the centre to the crucibles. Thus the total drainage gravitates to either tap-hole. It may happen that the hearth becomes obstructed, so as to throw more of the flow to one of the crucibles and less to the other. Such a result, however, need not interfere with the effective operation of the fore-hearths. Both crucible and hearth are made of silica brick, which has been found to be very enduring with the 40 per cent. silica slag here produced.

"Above the upper tier of jackets comes the heavy mantel-plate, 2 ft. 3 in. high, having a sloping front, and surmounted by the apron or receiving-plates, 21 inches high, with a slope of 45 degrees, both together making a hopper, upon which the charge slides down, tending to keep the finer portion closer to the walls, and the coarser material at the centre of the furnace, all of which helps to promote regular working.

"The furnace has a closed top, the fumes being carried off by three down-takes to the large dust-chamber adjoining the blast-furnace building. There are forty-six tuyeres at the back, and forty-two at the front side of the furnace, or eighty-eight in all, set at 14-inch centres. The space supplementing the lesser number of tuyeres at the front is utilised to make room for the two slag-spouts. It is customary to plug, or leave off, the four tuyeres nearest the ends of the furnace, as this is found somewhat to prevent accretions, so that practically only eighty-four tuyeres are used. The omission of the two tuyeres over the spouts does not appear to interfere with the proper operation of the furnace at this point, all of which indicates irregular working of tuyeres. Where it has been undertaken to cut out every alternate tuyere the furnace has not worked so well. This, indeed, may be due to the fact that some of the tuyeres cut out were in good working position, or, rather, that the more frequent tuyeres mean more chances of getting air into the furnace. The tuyeres are punched several times on a shift, and it can hardly be supposed that all the air enters the furnace by the small 1-inch hole thus formed. No doubt a good deal gets in between the jacket and the crust, eventually finding its way by devious passages (those of the least resistance) to the interior of the furnace.

"The bustle-pipe extends completely around the furnace, with two branches from the blast-main, each with its own shut-off gate, so that, to shut down the furnace, two valves must be closed. The tuyere-pipes are 5 inches in diameter; the tuyeres being bolted to the jacket for easy removal in case of necessity. The connection to the blast-pipe is made by a galvanized-iron sleeve, with a ring-clamp to make the joint tight. The fore-hearths, or settlers, of the former smaller furnaces, serve equally well for the large ones. They are 16 feet in diameter and 5 feet high, the matte-tap being 3 feet below the top of the fore-hearth. The slag enters on the side adjoining the furnace, and flows out on the opposite or front side. Experiments at Great Falls show the best point of outflow to be opposite the point of entrance. The discharging slag flows down a steeply-inclined spout, which delivers it

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opposite a 6-inch flattened water-jet situated just below the floor. This is supplied by jacket and other water. Besides this, there is a flow of water from the encircling cooling-pipe of the fore-hearth, which contributes to the stream that sweeps away the granulated slag through a semicircular cast-iron lined launder, and conveys it to the dumping-point on the flats below the works.

"The exterior of the furnace, having so long a side-wall, is braced and prevented from bulging by ties, carried around the furnace both at the level of the top of the lower jacket, and also under the floor. The horizontal pull of this bracing at the corner posts of the furnace is resisted by inclined ties attached to the floor above at adjoining corner posts. It will be noticed that between the three panels forming the length of the furnace, the jackets are supported by I-beams of the length of the panel (22 feet). Two sets of the I-beams are to resist outward pressure of the jackets, the upper and heavier set to hold up the upper jackets when the lower ones have, for any reason, been removed. Two of the outlet, or down-take, flues (soon to be changed to resemble the central one) are of steel, lined with brick, and have hopper-bottoms for the removal of the flue-dust. The third, or central down-take, has an upward and then a downward slope, having a pitch so steep that no flue-dust can rest upon it. Flue-dust, on the upward-sloping flue, slides back to the furnace; on the downward-sloping side it goes to the dust-chamber.

"The dust-chamber, 40 feet wide and 280 feet long, is provided with sheet-steel pyramidal hoppers, by which the flue-dust is conveniently drawn off to the charge-cars when they are run in below. This chamber, 20 feet high, affords a liberal space for the settling of the flue-dust. It is connected to the stack by means of a flue of 20 feet by 15 feet, or 300 square feet area of cross-section.

"*Operation.*—The furnace is charged through seven doors on each of the long sides, giving access to the entire length. It also has end doors for barring-out. The charge is brought in by a train of eighteen cars at a time, each car holding 2·5 tons. Eight of these cars constitute a charge, amounting to from 18 to 20 tons. The coke is charged separately in two-wheeled buggies, each of 30 cubic feet capacity, and capable of holding 1,000 lb. The amount used is 10 per cent. of the charge.

"The weighing of charges to an eighteen-car train is thus performed: The cars are spotted to the coarse concentrates bins, where the specified quantity is weighed in (to two at a time), the flow being controlled by a slide-gate operated by hand. A swinging chute, operated by a compressed-air cylinder, also assists in controlling the discharge. After the concentrates, the eighteen cars are simultaneously charged with the briquettes, as more fully mentioned in the description of the briquetting-plant. The train is then taken to the first-class ore bins, for the next item of the charge, then to the slag bins and the limestone bins. It will be seen that, in this way of putting in the materials, the finer portion is at the bottom of the car, and it is so charged into the furnace that it falls to the near side, while the coarser material goes to the centre portion of the furnace.

"The temperature of the gases from all the furnaces, in the flue beyond the dust-chamber, drops as much as 62 degrees C., and the draft-pressure drops ·2 inches of water when six of the forty-six doors are open. The air with a draught-pressure of 1·7 inches in the flue has a velocity of 1·5 feet per second through the doors (each of 20 square feet area), and with six doors open, an

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admission of 10,800 cubic feet per minute, or one-fifth of the total outgoing gases. The quantity entering is proportional directly to the number of doors opened. Of the total heat developed by the burning of the coke and sulphur, 18·6 per cent. escapes in the outgoing gases, which, at the entrance to the down-take, have a temperature of 380 degrees C. Not more than these six doors need be opened at any one time, either for charging or for cutting accretions or crusts from the furnace.

"With regard to the influence of limestone, comprising approximately one-third of the charge, whose decomposition into CaO and CO_2, completed at 800 degrees C., abstracts heat at the surface of the charge, and thus lessens overfire; such decomposition takes 425 pound-calories per pound of limestone, or, as 3·5 lb. limestone is used per pound of coke consumed, it absorbs 1,487 calories out of the total of 6,680 calories developed by the combustion of this pound of coke and the 1 lb. of sulphur which is disposed of at the same time.

"On the other hand, at the zone of fusion, the CaO, in forming a silicate, evolves 297 calories, where such an evolution is most to be desired, resulting in an outflowing slag which reaches a temperature of 1,150 degrees C.

"The temperature of the escaping gases varies from 100 degrees C., in a freshly-charged furnace, to 560 degrees, just before a new charge is put in, especially when there has been a longer interval than usual before again charging. These variations become greater as the jackets become more crusted over, such accretions forming to the thickness of several inches.

"The addition of a fresh charge results in a drop of temperature of 200 degrees C., while the opening of the doors on one side cools the gases 80 degrees C., the difference, 120 degrees, being due to the putting in of the cold charge. There results a gradual rise of temperature of 25 degrees C. per minute, the rise being retarded because of the endothermic action of the limestone, the evaporation of the water, and the heat absorbed in heating up the charge.

"It would be well to note here, that with a fusible self-fluxing charge containing but little limestone, and with so high a percentage of coke, this rise of temperature would be more rapid, and overfire would increase to such a degree, indeed, as to promote the greater formation of accretions which tend to crust over the top of the charge and to delay, if not stop, smelting.

"With regard to the charging operation, I am not at liberty to give the proportions or analyses of the constituents of the charge at the Washoe plant, but, in Table I, I present a typical Montana blast-furnace charge made up from data in Professor Hofman's paper, 'Notes on the Metallurgy of Copper of Montana.' The analyses of matte and slag are from the same source, and from Peters' book on 'Copper smelting' (7th ed., p. 552). Compared with the charge calculation given by him on p. 367, there is but little flue-dust made. To-day, all fine concentrates are sent to the roasters, and then to the reverberatory furnaces. The fine ore is also screened out from the first-class ore, and is worked into briquettes. Thus the flue-dust loss has been cut from 18·75 per cent. (which he mentions) down to 3 per cent. in present practice. The grade of the matte has also been reduced from 50 per cent., the practice at the time the book was written, to 40 per cent., as now made. It is now possible to work 40 per cent. copper matte successfully in the converter, because of the firmer quality of the lining due to the power-rammers used. The loss by volatilisation, 80 per cent. of sulphur, has, in spite of the large amount present, resulted in giving a 40 per cent. matte.

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This has been brought about, in part, by the use of a high-pressure blast of 40 oz. per square inch, which shows itself in much overfire and by the violent agitation of the materials at the surface of the charge.

"The high pressure of 40 oz. is necessary because of the small openings by which the air enters the surface, consisting of holes no more than 1 inch in diameter, where the slag has been pierced by the punching-bar, and of accidental seams between the jacket and its adherent crust, as well as by cracks and seams in this crust. The estimate allows for no leakages about the tuyeres, and the sound of escaping air indicates there is some loss from this source—a defect due to faults of construction, since, with the much higher pressures carried by the iron blast-furnace, the furnace-room is comparatively quiet. It may also be concluded that, with a more unrestrained entrance for the air, the pressure might well drop to half its present value, and that, moreover, with twice the volume of air now entering the furnace twice the tonnage could be put through. It is true, in the case of these large furnaces, that improvement has been incompletely met in other details. The same feeble methods are used to day in punching the tuyeres, and in barring-down the large furnaces, that have been used for many years. Improvement in the delivery of air at the tuyeres is the direction in which improvement will best be repaid. It would result in a furnace needing a low smelting column, in the dropping of pressure and, with it, the saving of power, as well as the ability of the furnace to increase its tonnage with the increase of the air admitted.

"Crusts or accretions are to-day removed by attack from feed-floor level by a gang of three or four men, who, exposed to the high radiant heat and fumes at that point, feebly work a heavy bar to break down these accretions. I believe, however, that metallurgists are well aware of these defects, and at this particular plant they will endeavour to remove them as soon as they can get to it. It must be remembered that the first of those 51-feet furnaces has been in operation only since March, 1904, less than a year before the present writing. There seems now, however, but little chance of the solution of the problem of improved air-supply into the furnace when one takes into consideration its difficulties.

"As indicated, there is a track at a level 10 feet below the slag-floor. The matte-ladles are run in and spotted to the desired furnace, and the fore-hearth tapped to the ladle. A dolly, having a 6-inch button-head, carries the conical clay stopper, made of a local clay. A full ladle of matte of 10 tons is drawn off. The flow is stopped with the dolly, the tapper pressing it in with all his force, while an assistant strikes the head of the dolly. The opening having been stopped, the tapping-bar is gently driven through the fresh clay, remaining there until the next tapping. The launder, leading the matte to the ladle, is 12 inches wide, with a semicircular bottom lined with clay. There is an independent launder to the other settler also, so that it is possible to tap from both fore-hearths to the same ladle. The ladle, when spotted, is ventilated by a hood suspended above it, which, terminating in a straight stack through the roof above, carries off the fumes.

"It has sometimes, though seldom, happened, as after a shut-down, that the contents of the fore-hearth have become cooled. Directly after tapping the matte, and before the settler has again filled with slag, it has been warmed by blowing compressed air into the settler, so as to bessemerize the molten matte still remaining in the settler. The reaction, being exothermic, serves to raise the temperature of the molten contents."

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TABLE I.—Charge-sheet.

Name of Ore.	Moisture.	Weight.		Cu.		SiO_2.		Fe and Mn.		CaO and MgO.		S.	
		Wet.	Dry.	Per Cent.	Wt.	Per Cent	Wt.	Per Cent.	Wt.	Per Cent.	Wt.	Per Cent.	Wt.
Coarse concentrates ..	3·0	1,550	1,500	8·7	130	22·0	330	27·0	405	..	....	35·7	535
Briquettes.....	8·0	1,620	1,500	6·9	104	45·0	675	11·0	165	..	....	17·0	255
First-class ore	3·0	2,060	2,000	8·0	160	50·0	1,000	12·1	242	0·5	10	15·4	308
Converter-slag.....	..	1,500	1,500	2·0	30	30·0	450	42·9	643	1·0	15	0·7	10
Limestone.....	..	3,500	3,500	..	..	5·0	175	1·0	35	51·0	1,785	..	..
Coke	..	....	1,020	..	..	6·9	70	1·2	12	0·8	8	0·7	7
	..	10,230	....	..	424	..	2,700	..	1,502	..	1,818	..	1,115

Weight of slag. $\frac{2,700}{40 \text{ per cent.}}$ = 6,750 lb., or 66 per cent. of charge.

Cu in slag, 6,750 by 0·33 per cent. = 22 lb., or Cu_2O = 25 lb.

Cu in matte, 424 — 22 = 402 lb., and the matte weighs, $\frac{402}{40 \text{ per cent.}}$ = 1,005.

Fe in matte, 1,005 by 30 per cent. = 301 lb., leaving for the slag 1,502 — 301 = 1,201 lb., or of FeO 1,544 lb.

S. in matte, 1,005 by 23 per cent. = 231 lb., and in slag 26 lb., or in both 257 lb.

S. volatilised 1,115 — 257 = 859 lb., or 77 per cent. of the total sulphur.

From these data we have in the slag SiO_2 2,700 lb. (40 per cent.); FeO, 1,526 lb. (22·5 per cent.); CaO, 1,818 lb. (26·9 per cent.); Cu_2O, 25 lb. (0·4 per cent.); S., 26 lb. (0·4 per cent.); other bases, by difference, 9·8 per cent.

From Peters[1] we have taken a matte and used it in our calculation; of the composition, S, 23 per cent. (231 lb.); Cu, 40 per cent. (402 lb.); Fe, 30 per cent. (301 lb.); other bases, 7 per cent. (71 lb.).

The matte fall, based upon the entire charge of 10,230 lb., is 10 per cent., and the concentration 5 tons of ore into 1 of 40 per cent. matte.

"ROASTING PLANT.

"*Reverberatory furnaces.*—There are seven reverberatories, the largest of the kind in the world, placed in two buildings. Each furnace supplies waste heat enough for two 300 h.p. Stirling water-tube boilers. The gases, after passing through the boilers, are conveyed by the reverberatory flue to the main flue. Whenever it is desired to clean the boilers, a by-pass flue conveys the escaping gases direct to the reverberatory flue, the connection through the boiler being meanwhile shut off.

"Length of hearth, No. 1, 115·8 feet; of Nos. 2, 4, and 5, 102·5 feet; and of Nos. 3, 6, and 7, 112·5 feet; all hearths are 19 feet wide, and have fire-boxes 16 feet by 7 feet, or 112 square feet area. Referring to furnace No. 1, the outlet-flue at the neck is 60 by 38 inches, or of 16 square feet area. The skimming-door, 12 inches by 15 inches wide, has its skim-plate 4 inches above the hearth at that point. The hearth, however, has a slope of 8 inches towards the matte tap-holes. At 24 feet from its front end, the furnace begins to draw into the jamb, where it is 7 feet wide and 4 feet high to the crown of the arch. The rise of the arch is 1 inch to the foot, or at the middle section is 19 inches. In the roof there were ten transverse

[1] Modern American Methods of Copper Smelting, by E. D. Peters, jr., 7th ed., p. 562 (1895).

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expansion-joints, 3 inches wide, or 30 inches in all left in the furnace when built. These, however, are now each a little more than 1 inch when the furnace is cold. In the bridge itself there are three transverse expansion-joints, each of 4 or 5 inches, which close up when the furnace is fully heated. The bridge is 4 feet across, and is 27 inches above the hearth and 24 inches above the grate. It has a hollow conker-plate, through which air passes by a ventilating passage to the draft-flue, thus keeping the bridge cool. At this end of the furnace the height from the hearth to the crown of the arch is 6·7 feet. Twenty checker holes, each 3 by 3 inches, provided for the admission of air, are located transversely to the furnace over the fire-bridge.

"In some of the furnaces additional checker-holes have been made at the front of the fire-box for additional air, but for other furnaces this extra supply is not needed. In order to determine the height of the coal in the fire-box, two circular stoke-holes, 12 inches in diameter, are placed in the front wall of the fire-box, and these openings are closed by wheel-doors. Over the middle line of the fire-box are four charge openings, 12 inches square, through which the four coal-hoppers discharge into the fire-box. There are ten side doors, each 8 by 15 inches, with sills 18 inches above the level of the skim-plate at the front. The sides of the furnace and the fire-bridge are stepped off for several courses on the inside, thus strengthening the lower portion of the walls and the bridge. There are four charge openings in the roof, having circular covers. Through these openings the charge from the two hoppers above drops into the furnace.

"The operation of these furnaces is as follows :—In the fire-box of a furnace, which has been shut down for repairs, a fire of wood is put, followed by an increasing firing of coal, until, in forty-eight hours, the first charge may be dropped in. As fast as charges are melted, others are added until the furnace has been filled. The furnace takes from ten to fifteen days to get up to its full heat. The charges of 15 tons are put in, on the average, every eighty minutes, 10 tons being dropped from the first hopper and 5 tons at the second one, 90 feet from the front of the furnace. It must be noted that the charge drops upon a bath of a minimum depth of from 3 to 4 inches of matte with 8 inches of slag above it, so that there is little chance of the new charge sticking to the hearth. The hot calcines, of which the charge is principally composed, spread out less than commonly represented. There is, however, a movement of the entering charge towards the front of the furnace, in consequence of which the ore may be observed floating down in two ridges towards that end, and gradually spreading out. Heat is taken up not only from the flame, but also from the highly-heated molten bath of the furnace, in consequence of which fusion proceeds rapidly.

"Before dropping the next charge, the side-door near the hoppers is opened, and a rabble inserted to determine that no unfused material remains. It sometimes happens that some of the charge becomes agglomerated, and, moving down towards the front end, escapes fusion. These 'floaters,' as they are termed, are moved up toward the fire-bridge by inserting a rabble at the proper doors, so that they are brought to the hottest part of the furnace and then fused; or, better, a pipe is inserted under them by which the matte just under the floater is bessemerised, and the mass melted at the increased temperature resulting. Skimming is performed every four hours, care being taken, however, to do it not less than forty-five minutes after a charge has been dropped. It takes about fifteen minutes, the amount run out being from 45 to 50 tons. The slag is granulated in water, and is run to waste by a launder to the dump. This operation, called skimming, is rather a tapping, the rabble being used to hold back and control the speed of the

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outflowing stream of slag. A rabble with a 5-inch by 9-inch blade and a 12-foot handle is used, and sometimes a larger one, having a 6-inch by 16-inch blade. The slag runs through a settling-pot, or trough, 7 feet long, 24 inches wide, and 18 inches deep, intended as a safeguard against a possible escape of matte. The slag adhering to this pot is called pot-slag, and is sent to the blast-furnaces, since it may contain drops of matte. When as much as 200 tons of matte has accumulated in the furnace, it is tapped off, according to the amount of matte needed at the converters. The matte flows into a 10-ton ladle from two reverberatory furnaces, 80 feet distant. A compressed-air locomotive is coupled to the ladle-car, ready to move it when full. Quite commonly the matte is tapped from two furnaces simultaneously, the runner or launder, 80 feet long, branching to the adjacent tap-holes of the two furnaces. These tap-holes, two to each furnace, are at the hearth level. The plugging of a tap-hole is done with a stopper-rod, or dolly, having a button of 4 inches diameter, on which is stuck a conical clay plug. This is inserted by one man, whose efforts are seconded by another, who strikes the end of the dolly with a heavy hammer, to enter the plug effectually into the tap-hole.

"Coal is charged into the fire-box about once in forty minutes, dropping in 3,000 lb. of coal at the four charge-openings. The level of the coal is found by feeling it with a rod introduced through the stoke-openings at the front of the fire-box. A mica-covered hole, located in the outlet flue of the furnace, can be observed by the fireman 125 feet away, who regulates the firing of the fuel by observing the appearance of the flame at this hole. The coal is carried on the grate to the height of the bridge, or about 24 inches, and a clinker-bed is permitted to form on the grate-bars. These bars, 2 inches square and 6-inch centres, permit a good deal of ash and unburned coal to fall through. The dropping of these materials is constant, the coke amounting to 10 per cent. of the total coal used.

"About monthly it is necessary to patch or fettle the furnace near the fire-box end, where it is subjected to the greatest action of the fire. This is known by looking in at the slot of the fire-bridge, where the conker-plates are observed becoming red-hot. Repairs having been determined on, the matte is allowed to accumulate in the furnace to near the level of the sill of the skimming-door. Slag is tapped and skimmed close to the matte, and then the latter is tapped dry from the furnace. Such a large amount of matte will fill a train of sixteen ladles. To take care of it, preparations have been made by having withdrawn matte just before from the blast-furnace settlers or fore-hearths. Thus full attention can be given to this supply at the converters. At the reverberatory half the matte is tapped off into ladles and covered; the remainder is then treated in the same way. The first three side-doors of the empty furnace are opened and about 20 tons of sand, used for fettling, thrown in against the corroded sides, as well as placed there by means of paddles. To tap the matte and to repair the furnace requires more than eight hours after which the doors are put up, the fires urged, and new charges added until 250 tons of ore has been put in. About once in eight months it becomes necessary to repair the furnace fully, when it is tapped dry and allowed to cool off until it is possible for the masons to enter. This waiting may be lessened by admitting a blast of air from a fan to ventilate the portions of the furnace where the repairing has chiefly to be done, viz., the 25 or 30 feet at the fire-box.

"These reverberatory furnaces can smelt from 250 to 325 tons daily, and may be termed 300-ton furnaces. They burn from 55 to 60 tons of coal in twenty-four hours, or 21 per cent. of the charge. It must be remembered

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that about 10 per cent. of this, however, is recovered in the cinders as coke. At $4·50 per ton for coal this would make $1 per ton of charge treated, to say nothing of the 600 h.p. of steam obtained from the waste gases. On account of the large body of matte and slag carried in the furnaces, the variations of temperature are less than in smaller ones. Skimming or tapping is all done at the front door, where the entering air will not cool off the furnace. Care is taken to lute up all openings, and upon the cooler front-half of the furnace-arch, to carry a layer of 3 inches of sand to retain the heat and to stop every crack. When the sand is removed at any spot upon the arch, red-hot brick shows itself. The charge being dropped near the fire-box end, the dust has a chance to settle in going the long distance of 100 feet through the furnace, so that the loss by flue-dust is small. With a furnace-width of 19 feet distant from the centre-line of the furnace and hence far from the heat, the corrosive action is less than in a narrower furnace.

"A type charge of these reverberatories consists of calcines, limestone (put into the charge at the McDougall roasters), and flue-dust, containing—SiO_2, 26·1; FeO, 31·3; CaO, 2·9; S, 8·1; and Cu, 9 per cent. The slag contains SiO_2, 37·8; FeO, 38·6; CaO, 4·6; Al_2O_3, 6; and Cu, 0·37 per cent.; and the loss of sulphur by volatilization is 33 per cent. Corresponding reverberatory-slags at Great Falls, Mont., show Cu, 0·69 per cent.; the higher copper-content, as compared with that of the Anaconda slag, being due—(1) to the lower temperature and hence less fluid slags, (2) to the better settling in the longer furnace, and (3) to the greater amount of lime contained in the Anaconda slag. The matte is tapped, through plates 24 by 24 by 2·5 inches, to the matte launders, which convey it 80 feet to discharge it to the ladles. Two ladlesful of matte are generally drawn at a time without stopping the flow. It is found that but little matte is spilled in moving the empty ladle into the place of the full one. The best point to which to roast the calcines for good reverberatory work is from 7 to 8 per cent. of sulphur."

The blast furnace, as well as the reverberatory and calcining furnaces in the smelting works of the Washoe Copper Company at Anaconda, have been enlarged, and now upwards of 10,000 tons of ore are treated daily.[1]

Permanence of Copper Lodes.

The permanence of copper lodes may be gauged by two factors—duration of operations, and actual depths of workings combined with extent of output. The first is applicable to deposits whose early history is obscured in the haze of intervening centuries; the latter, to mines in operation. In whichever light regarded, the prospect is cheering. Copper lodes, judging by history, are among the most persistent metalliferous repositories in Nature; it seems almost superfluous to add that this statement applies only to important occurrences.

Japan furnishes remarkable instances of the longevity of copper mines, which rank first in the mineral wealth of the country. In the "Mining Industry of Japan during the twenty-five years—1867 to 1892"—by Wada Tsunashiro, Director of the Mining Bureau, Department of Agriculture and Commerce, it is stated that "Yoshioka and Osaruzawa Copper Mines, with several silver and gold mines, started in the the 9th century, are still working and prosperous." At the World's Fair, Chicago, the Writer was informed by Mr. Rejii Kanda, Mining Commissioner for Japan, that vertical shafts sunk under his engineering supervision to depths

[1] Report of the Amalgamated Copper Company, 30th April, 1907.

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of over 1,000 feet had revealed early workings extending even below that level. From these great depths the ore was carried to the surface in baskets on men's backs, through galleries or levels connected by short ladders. This primitive system of mining was admirably illustrated by models in the Japanese Mining Court at the World's Fair.

In England[1] the Cornish tin lodes were worked in the time of the Phœnicians. With depth, copper ores replaced those of tin, and still deeper, the latter reappeared. Copper-mining in England began about 1700; previously the metal was obtained chiefly in connection with tin-mining.

The famous Tharsis and Rio Tinto Mines of the Spanish Peninsula were worked by the Romans, and are still in operation on a scale of great magnitude (2,457,470 tons of cupriferous pyrites were extracted by the Rio Tinto Company alone in 1905), with an estimated reserve proved by drill borings equal to 130,000,000 tons.[2] The timbers in the old Roman workings have been so preserved by the copper salts in solution as to retain markings and letters cut by Roman miners eighteen centuries ago.

A local instance of the preservative qualities of certain mineral solutions may be cited; the time test, though comparatively extremely limited, is none the less effective. The timbers in the Moruya Silver Mine—the first silver mine opened in the Colony, laid down about 1861 or 1862—which have recently been exposed by unwatering the old workings, are in an excellent state of preservation. A more interesting fact, perhaps, is the condition of the ironwork: even the nails and ladder clips are capable of re-use; the latter, in fact, have been re-forged and used in the renovations. The Moruya ore is essentially arsenio-pyrite, with occasional zinc-blende. The preservative agent is, therefore, probably chiefly arsenic.

Copper mines in Portugal, worked by the Romans, are still in operation. The celebrated San Domingos Mine yielded 196,922 tons of cupriferous pyrites in 1894.[3]

Italian mines, worked by the Etruscans, and during the Middle Ages, were brought to a standstill in 1630 for more than a century, when operations were resumed and are still in force, the 1,000-foot level being passed.

Swedish copper mines have been worked from a very remote period. According to Vogt (quoted by Phillips and Louis), the Falun cupriferous pyrites deposit has produced 1,200,000 tons of copper, equal to 35–40 million tons of ore, since the year 1200; and now produces annually about 500 tons of copper.

In India very ancient copper mines exist, but copper is now only produced on a very limited scale.

An idea of the permanence—or persistence in depth—of more recent mines can be gleaned from the following figures relating to some of the prominent American mines. Even under most favourable circumstances the duration of mines in this age of severe competition, and enormous outputs to meet increasing demand, must necessarily be comparatively extremely limited, when contrasted with early historic mines worked by primitive methods to satisfy restricted needs, though the actual extraction will probably compare most favourably. It is necessary to note that the Lake Superior copper

[1] J. A. Phillips and H. Louis' Treatise on Ore Deposits, 1896, pp. 190 and 229.
[2] Stevens—The Copper Handbook, 1906, pp. 866–868.
[3] Phillips and Louis' Treatise on Ore Deposits, 1896, p. 515.

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deposits are not lodes in the ordinary acceptation of the term, but bed-deposits (conglomerates), flow-deposits (amygdaloidal lavas), and vein-deposits (small fissures in the igneous flows), which are followed on the incline.

DEPTHS OF SOME AMERICAN COPPER MINES.

Name of Mine.	Depth—Vertical.	Depth—Inclined.	Dip.	Temperature.	References.	Remarks.
	feet.	feet.		degrees.		
Red Jacket, Lake Superior	4,200	....	..	87·6	United States Geol. Survey, 17th Ann. Rept., Pt. 3, p. 94.	
Tamarack, ,,	3,409	....	..	....	Stevens' Copper Handbook, 1906, pp. 954 and 955.	No. 1 shaft
,, ,,	4,255	....	..	....		No. 2 ,,
,, ,,	5,139	....	..	....		No. 3 ,,
,, ,,	4,450	....	..	....		No. 4 ,,
,, ,,	3,300	....	..	....		No. 5 ,,
Quincy, ,,	....	5,000	..	....	*Ibid.*, p. 838.	
Calumet and Hecla, Lake Superior.	4,748	8,290	37½	....	*Ibid.*, p. 810.	
Butte, Montana	2,600	....	..	....	Mineral Industry, 1906, p. 211.	

Cutting the Calumet and Hecla lied on the underlay at 4,185 feet.

The rich secondary (subsulphide) ores of Butte are estimated by Ledoux[1] to decline at the rate of 2 per cent. per 100 feet, but this diminution lessens according to Dr. Peters, as greater depth is reached, and is about stationary at 1,300 feet. The actual smelting yield at the present time is computed to be about 3·25 per cent. of copper, and average values of $1·75 to $2 gold and silver per ton.[2] Owing to improvements in metallurgical treatment, and to consolidation of properties, the Butte mines are reported to be making more profit out of this lower grade than was possible with double the yield before.

The Lake Superior ores are reported to have an average value of about 2 per cent. of copper, but some mines yield only ·75 per cent. The Tamarack output in 1905 averaged about 1 per cent.[3] The profitable working of these low-grade deposits to the immense depths quoted above depends upon the unique occurrence of the copper in the native state, which dispenses with costly reduction plants. The copper is so pure that simple concentration and melting are alone necessary to secure for it the highest market values.

"THE COPPER MINES OF THE WORLD."

By Walter Harvey Weed, Geologist, United States Geological Survey.

Production.

"*Future supply and demand.*—The question arises where the future supply is to come from. Copper mines are not inexhaustible; and every pound of ore extracted means just so much less in the ground. The old sources of

[1] Modern Copper Smelting, 9th edition, p. 20, 1898.
[2] Stevens—Handbook of Copper, 1906, p. 194. [3] *Ibid.*, p. 954.

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supply, though not exhausted, are getting nearer and nearer to extinction and reaching more or less rapidly the point of exhaustion. Though the long life of copper mines is well established, they cannot last for ever. As Rickard has said, 'Even Methuselah died.'

"Some of the Huelva mines of southern Spain, worked since Roman days, are already exhausted; the Rio Tinto ores are gradually getting leaner and leaner, and the region is barely holding its own as a copper producer, despite the prevailing high prices. The Montana mines have increased their output to nearly 20,000 tons of ore a day, and several mines are 2,400 feet deep, they cannot last for ever, and the district must see a decline some day, though fortunately it is not yet in sight.

"Lake Superior will hold its own for many years to come, owing to the opening of new mines; but the older ones, the best payers, are already a mile deep, and working costs, if not leaner ore, will limit their downward extension.

"Europe, Asia, Australia, and Africa produce copper, but the production is stationary or declining. South America is said to have untold wealth in copper, but the economic conditions are so unfavourable that, with the exhaustion of the rich secondary ores, the deposits are often abandoned.

"The present and future increase will, it is believed, come from North America; first from Nevada, Utah, and Mexico; next from British Columbia and Alaska.

"Copper mining is becoming a more stable industry with the development of great bodies of low-grade ore, rather than the rich but usually limited deposits of the earlier stages of mining. The development and operation of low-grade deposits necessitates large plants, cheap fuel, and cheap transportation, as well as a very large amount of invested capital. In undeveloped and remote regions it is only the very rich ores that can yield a profit, and hence in the opening up of a new country or section, as in western North America, Central Africa, and Asia, the low-grade deposits are the last to be developed."

"The Mineral Industry during 1906."

Edited by W. R. Ingalls.

"*Consumption.*—The domestic consumption of copper in 1906 was far in excess of anything previously known in the United States, the average being about 55,660,000 lb. per month against about 51,000,000 per month in 1905. All the mills manufacturing sheet, wire, and other finished forms of copper, all the brass mills and all the manufacturers of machinery into which copper and brass enter in part, were extremely busy throughout the year. The great extension of electrical work of all kinds, the construction of new electric roads and the application of electricity on existing railroads were largely responsible for the demand, which shows every sign of continuance through 1907. The capital stock of the American Brass Company, the largest consumer of copper, was increased from $12,500,000 to $15,000,000, on 26th February, 1907. About 15,000 men were engaged in the brass industry at Waterbury, Conn., in 1906. There were considerable additions made to the various manufacturing plants, including those of competitors as well as subsidiaries of the American Brass Company. In some of the shops the men worked on relays, and in the casting mill they were employed for twenty-four hours daily. The Waterbury Brass Company erected a new rolling mill."

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Depths of New South Wales Copper Mines (Vertical or Inclined).

The depths attained in New South Wales are, with two exceptions, comparatively, very superficial :—

	Feet.
Burraga (following underlay)	2,135
Great Cobar	1,000
Crowl Creek	730
Nymagee	720
Cobar Chesney	700
Lake George Mines (Captain's Flat)	700
Cangai (by tunnels and winzes)	600
Queen Bee	563
Great Cobar North	560
Girilambone	544
C.S.A.	...
Belubula	504
Conrad Stannite	500
Shuttleton	450
Cobar Gold-mines	437
North Nymagee	400
Mount Hope	400
Frogmore	373
Bundarra	360
Cobar Copper (late Mount Pleasant)	340
Phœnix	340
Blayney	337
Ace	321
Adeline	310
Goodrich	300
Milburn Creek	300
Budgery	283
Icely	275
Federal	269
Mount Boppy Copper-mine	259
Snowball	259
Attunga	258
Bumbery	250
Apsley	240
Carangara	240
Cash-Essington	235
Belara	212
Mount Stewart	210
Budgerygar	203
Mount Royal	200
Underlay	200
Gulf Creek	200
Summerhill	200
Nadbuck	200
Mount Laut	200
Ophir	200
Currowong	186
Coombing Park	180
Belmore (near Lewis Ponds)	180
Cow Flat	180
Mountain Run	180
Mulloon	175
Big Wertago	170
Gurophian	170
Canbelego	170
North Wiseman's	162
Summer's Copper-mine	155
Balmoral	155
Copper Well	150
Vychan	150
Bogan River	150
Orange Plains	150
Elizabeth	150
Lobb's Hole	147
Copper Hill	146
Mount Everest	145
Bobby Whitlow	142
Belmore (Cow Flat)	140
Quigley's Hill	140
Sydney—Walleroo	140
Eclipse	140
Mount Ragan	138
Green Swamp	135
Sugarloaf	135
Box Ridge (Summerhill)	130
Kyloe	130
Cooma	129
Mayfield	125
Ophir	120
Nelson	120
Bob's Mount	120
Cootralanta	118
Lucky Hit	115
King of England	110
Dartmoor	100
Monaro	100
Mount Jasper	100
Native Bee	90
Merilla	86
Namoi	83
Kangiara	83
Wilpina	80
Boro	80
Cadia Extended	80
Willi Willi	75
Cowfell	75
Cyclops	70
Esmeralda	70
Bredbo	64
Little Copper Hill	64
Moonta	60
Pluck	50

Bedded Copper Deposits (Sedimentary).

The celebrated Keupferschiefer, or copper schist of Mansfeld, Harz, Germany, is the most important example of this form of deposit, apart from those of Lake Superior, which consist of lava flows with interbedded conglomerate. A brief description of its occurrence will be found in another

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portion of this work. The Mansfeld copper-beds belong to the Permian period; those of New South Wales to the Triassic. The latter will be described at some little length because of the scientific interest attaching to the occurrence, which otherwise has no value. The association of copper ores with Permian strata is as world-wide as it is remarkable. In Southern Russia, Germany, America, and Great Britain, beds of the Permian, or a closely approximating period, contain copper impregnations. Those of America, in California, Colorado, and Mexico, according to Dr. Peters,[1] are of Triassic Age, and therefore more closely allied in time to those of the Sydney Coal Basin, which received a good deal of attention from Geological Surveyor David, B.A., F.G.S., now Professor of Geology at the Sydney University.

The American deposits are of special palæontological interest in that the copper ore—glance—replaces fossil shells, fish, and plants.[2]

In a paper read before the Australian Association for the Advancement of Science in 1887,[3] Professor David stated "that cupriferous shales have been discovered at the following places:—

"1. At the 1,312-foot diamond drill bore, completed in 1879, at Newington, on the Parramatta River, near Parramatta, where it was observed by Mr. Waterhouse.

"2. At Bulli. The shale is said to outcrop on the hills at a level of about 700 feet above the Bulli coal-seam.

"3. At the 2,307-foot diamond drill bore, completed in 1887, at Dent's Creek, on the Holt-Sutherland Estate, between Port Hacking and Botany Bay.

"4. At the 1,586-foot diamond drill bore, completed in 1886, at Heathcote, on the Illawarra line, 27 miles southerly from Sydney.

"At Holt-Sutherland, out of a total thickness of 71 feet, at least 3 feet showed native copper, more or less freely. At Heathcote, about 7 inches of core altogether were cupriferous."

The following analysis of the tuff (Holt-Sutherland) has been made by Mr. J. C. H. Mingaye, F.C.S., Analyst and Assayer to the Department of Mines:—

Combined moisture	5·32
Moisture at 100° C.	3·38
Silica	56·28
Alumina	24·21
Oxide of iron	7·34
Metallic copper	·08
Lime	1·10
Magnesia	2·36
	100·00

Professor David, in the article quoted, discussed the economic value of the cupriferous tuffs, and summed up the question in the following terms:—

"At Holt-Sutherland the total thickness of the copper-bearing portions of the shales is at least 3 feet. This thickness, however, is made up of a number of different layers, several of which are separated from one another by bands of shale, which do not show copper freely, though they probably contain a small proportion of the same metals which occur in the more productive

[1] Modern Smelting, 7th ed., p. 18. [2] Eng. and Mining Journal, 19th November, 1892.
[3] Trans. Aust. Assoc. Adv. Sci., I, pp. 275–290.

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bands. The thickness of the metalliferous bands is respectively 1 inch, 2½ inches, 12 inches, 7½ inches, 5 inches, 2 inches, 2½ inches, and 6 inches. The highest ore-band is about 24 feet above the lowest, and the beds are separated from one another by from 1 foot to 9 feet of comparatively barren shale.

"At Heathcote there are two thin beds showing native copper, the upper 6 inches thick, and 7 feet above the lower, which is only 1 inch thick.

"Assuming, therefore, that a continuous bed of cupriferous shale extends from Heathcote to Holt-Sutherland, a distance of 8½ miles, having an average thickness of 1 foot, there would evidently be a large body of metalliferous strata.

"The average specific gravity being taken as 2·6, every acre of shale would contain 3,160 tons of copper-bearing rock, which would yield on the average (the average yield being assumed to be 0·15 per cent.) 3 lb. 5¾ oz. of metallic copper and 7 dwt. 7 grs. of silver per ton. If, therefore, the value of the gold be left out of consideration, and, as already stated, gold was only found in appreciable quantity in one doubtful assay, the value of copper and silver in the aggregate would be only 3s. 9d. per ton, so that the shale is far too poor to work at present for these metals.

"The cupriferous tuffs and tuffaceous shales are evidently partly of volcanic and partly of sedimentary origin, as proved by the presence in them of both basalt lapilli and rounded quartz grains. Two facts indicate Kiama, or the line of volcanic country between Kiama and Mittagong, as the probable source of the volcanic particles: first, the presence of minute segregated veins of metallic copper in the basalt at Kiama; second, the resemblance of the Kiama and Mittagong lavas to those of which the fragments in the tuff at Holt-Sutherland are composed." . . . .

In three slides of the Kiama basalt Professor David detected minute segregated veins of metallic copper, about 1-40th of an inch thick. The local horizon of the cupriferous basalt has been designated the "Bombo" lava.

The cupriferous shales outcrop on the coast at Narrabeen, a few miles north of Port Jackson. Here a little prospecting has recently been done under the impression that a lode existed. Carbonates and native copper occur, the latter, in some instances, forming concentric scrolls in fossil wood. The organic matter of the latter is carbonised, and has been the means of precipitating the copper in metallic form.

The cupriferous tuffs are noticeable in the cliff sections of the Blue Mountains on the same geological horizon.

South Australian Copper-mines.

The first lode discovered in South Australia, according to Mr. H. Y. L. Brown, Government Geologist of South Australia,[1] was the Wheal Gawler, a silver-lead mine on the western slopes of the Mount Lofty Ranges, 4 miles east of Adelaide, opened in 1841.

The first copper-mine—the Kapunda—was discovered in 1842; the next in order being the Montacute in 1843, the Burra in 1845. The Moonta and Wallaroo Mines were found between 1861 and 1864, and proved the richest in the Colony. They are situated on Yorke's Peninsula, on the eastern shore of Spencer's Gulf. The Moonta and Wallaroo Mines are about 9 miles apart, but are worked by the same company. The Moonta occurs, according to Mr. L. G. Handcock, in felspar porphyry, the Wallaroo in metamorphic schist.

[1] A Record of the Mines of South Australia, 1887–1890, opposite p. 28.

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Mr. Brown describes the Moonta in the following terms :—

"There are five main lodes on the property, and from each of these various spurs and minor lodes branch out, and are connected with the main lodes by occasional cross veins. Including these, there are twenty-seven lodes. Their direction is north-westerly, and their underlay varies from 3 to 6 feet in the fathom. The main lode bears N. 20° E., and the others vary from that up to N. 45° E. Their width ranges from 6 inches to 20 feet, and the ores obtained from the lodes in the present workings are chiefly chalcopyrite and bornite. The bulk of the veinstone—chiefly quartz, and at times portions of the bed-rock—as raised ore and gangue gives from 2 to 5 per cent. of copper, but sometimes clean chalcopyrite gives 20 to 30 per cent., and bornite from 30 to 50 per cent.

"The quantity of ore raised from the Moonta Mine from the commencement to June, 1886, equalled—in gross tons of 21 cwt.—476,180 tons, and the average percentage of copper on net dry weight of dressed ore equalled 20 per cent.

"The deposits of copper ore are chiefly along the lead of the lodes associated with gangue, at the present supplies being chiefly chalcopyrite and occasional bornite. An exceedingly small proportion of green carbonate ore was found close to the surface, but a large proportion of the green ore was atacamite. The deposit did not extend more than a few inches, or occasionally a few feet, from the surface.

"The peculiarity of this cupriferous district was disclosed by the removal of these ores and the sinking of the shafts, and was that although the lodes continued regular, no further ore was met with; and, as a rule, no stain of copper was seen until the depth of 5 to 10 fathoms (30 to 60 feet) was reached, when rich oxides and malleable copper deposits were struck, and after that black and grey sulphides."

Mr. Brown states that five lodes occur in the Wallaroo property, which is situated 10 miles north of Moonta Mine.

"The main lode is nearly vertical, although occasionally the underlay is a little to the north, and sometimes a little to the south. The lodes vary in width from 6 inches to 20 feet, and the ore they contain is chiefly chalcopyrite. As raised from the mine, it varies from 3 to 10 per cent., with occasionally small quantities of rich ore." Country, talcose schist.

To Mr. L. G. Handcock, son of the well-known late manager of these mines, the Writer is indebted for the following particulars of these mines in 1898 :—The lodes of Moonta vary in thickness from 3 to 8 feet, those of Wallaroo up to 20 feet. The Moonta ore at the present time does not average more than about 2 per cent. of copper in the crude, but it can be dressed to a much higher grade than that of Wallaroo, owing to the amount of pyrites in the latter, which, when cleanly concentrated, does not grade above 12 per cent.

The method of treatment at Moonta may be briefly described as typical of both. The ore is tipped on to a platform, where the attle or waste is picked out by boy-labour, a large percentage of the bulk thus being removed. The ore is then passed through rock-breakers and Cornish rolls. The screens average about five holes to the inch. The crushed ore is then jigged—water being obtained from the mine—and the "firsts" and "seconds" sent to the smelters, the tailings being discarded. Before, however, going to the jigs, the ore passes through agitators in which the coarse particles pass through the bottom holes, whilst the finer (slimes) are carried off by the current and

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over buddles. The concentrated slimes from the buddles are dried by spreading in the sun, and are subsequently charged in the furnaces with kiln-roasted ore.

The value of the outputs of the Moonta and Wallaroo Mines, which are now worked in conjunction, according to Mr. Brown, are as follows[1] :—

Moonta Mine, from commencement to 31st December, 1898, £5,113,252.

Wallaroo Mine, from commencement to December 31st, 1898, £3,906,277.

The greatest depths reached to end of 1898 being—Moonta, 1,500, 1,600, and 2,340 feet in different lodes; and Wallaroo, 1,170 feet.

Burra Burra Copper Mine, according to Mr. Brown, was found by a shepherd in 1845, about 100 miles a little north of west from Adelaide, situated on bald hills standing 120 feet above the surrounding country. The prevailing rock is limestone. The ores obtained from this mine have been chiefly red oxide, and very rich blue and green carbonates. Native copper was also found. For many years the average yield was from 10,000 to 13,000 tons of ore, averaging from 22 to 23 per cent.

In Mr. Conigrave's "Handbook of South Australia," it is stated that during the twenty-nine years in which the mine was worked, the Company expended £2,241,167 in general expenses. The output of ore during the same period amounted to 234,648 tons, equal to 51,622 tons of copper. This, at the average price of copper, amounted to £4,749,224. The mine ceased working in 1877. Greatest depth reached 600 feet.

The following particulars are extracted from the Official Catalogue of the International Exhibition, London, 1851, at which ores from the mine were exhibited :—Mine started 5th September, 1845, with a capital of £12,320. To September, 1850, the following amounts of ore were raised :—

	tons	cwt.
September 30th, 1846	6,359	10
,, 30th, 1847	10,749	17
,, 30th, 1848	12,791	11
,, 30th, 1849	7,789	16
,, 30th, 1850	18,692	9
Total	56,428	2 in 5 years,

varying in quality from 30 to 70 per cent. The money value of the output was £738,108.

Prior to September, 1850, the ore was shipped to Swansea, but at the local smelting-works then established and at the mine 1,000 men were employed.

It is worthy of note that no calls were made after investment of the working capital—£12,320—and that the value of the original £5 shares rose to £200. The shares returned £40 per annum in dividends, a total of £800,000 being so paid. The mine was afterwards sold to a new company, but for many years has not been worked.

Mr. Brown describes the mine as follows :—"In the deeper levels regular lodes are met with, running north and south, containing very rich ore, malachite, red oxide, and grey sulphuret of copper; but above the 30-fathom level (180 feet) there is no appearance of lodes, the ores (malachite and azurite) being deposited with the greatest irregularity. The blue carbonate often occurred in round nodules, with crystals of the

[1] Record of the Mines of South Australia, 4th ed., 1908, pp. 139, 140.

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greatest regularity projecting from the surface. The malachite was found in the form of stalactite, in slabs encrusting fissures, and irregularly-shaped masses, which had been deposited in cavities in the rocks. The country rocks are much broken and twisted, and consist of cherty silicious rocks, crystalline white and gray limestone, blue slaty shales, and argillaceous sandstones."

Queensland Copper-mines.

Peak Downs Copper Mine was discovered in 1862, according to Mr. W. H. Rands,[1] who stated that the lode could be "traced 1½ mile, running in an east and west direction. It has an underlie varying from 40° to 70° to the south.

"Country consists of foliated and contorted micaceous and hornblendic schists, dipping south-east. The outcrop is a gossan, consisting chiefly of red and brown hematite, with a little oxide of manganese and carbonates of copper. The ores were oxides and carbonates of copper to a depth of about 75 feet vertical from the surface, a mixture of oxidised ores and sulphurets to a depth of 120 feet, and below that depth they were ordinary sulphides of copper. The gossan at the surface was auriferous; assays of it gave from 4 dwt. to 1 oz. 16 dwt. of gold per ton, and also up to as high as 5 oz. of silver per ton.

"The deepest workings were 396 feet. Most of the lode was taken out to a depth of 240 feet for a distance of half a mile.

"From 1862 to 1878, when the original company was wound up, about 100,000 tons of ore, averaging 17 per cent., were smelted at the company's works, the value of which was £1,250,000."

Chillagoe.—Great results were anticipated from these copper-mines when railway communication with the seaboard was established. The lodes, according to Dr. R. L. Jack,[2] late Government Geologist of Queensland, occur as segregations or replacements of mechanically and chemically formed sedimentary rocks, also filling true fissures. The granite and porphyry of the neighbourhood also contain copper lodes. An important feature is the occurrence of silver and gold in the copper ores, which will probably have an important bearing on the metallurgical treatment to be adopted. The proximity of large and easily available water-power in the Barron Falls will, as Dr. Jack points out, prove a potent factor in ensuring commercial success in connection with the latter.

Mount Morgan, Queensland.

The famous Mount Morgan Gold-mine since 1906 has come prominently to the front as a copper producer. The Writer is indebted to the directors and officers of the Mount Morgan Company for facilities and information afforded during inspection of their mine and plant.

Mount Morgan offers a fascinating field for geological investigation and mapping. The oldest strata of the immediate locality are of Permo-Carboniferous age[3]; the youngest—Upper Cretaceous.[3]

The former have been extensively metamorphosed by massive hornblendic granite and quartz felsite intrusives; and by, at least, two later eruptions of andesitic dolerite dykes.[4]

The predominant rock in the vicinity of Mount Morgan is the hornblendic granite, which forms bold ridgy outcrops on the south, south-west, and west;

[1] On the Geology and Mineral Deposits of the Country in the vicinity of Clermont. (Pal., Brisbane, 1886.) Jack and Etheridge, Geol. and Pal. Queensland, 1892, p. 33.
[2] Bull. Geol. Survey Queensland, 1898, No. 9. [3] R. L. Jack.
[4] T. W. E. David and W. Anderson, Records Geol. Surv. N. S. Wales, II, Pt. 3, 1891, pp. 87–98.

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Open Cut, Mt. Morgan.

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Steam Shovel, Mt. Morgan.

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and is conspicuous on the north-east in railway cuttings and elsewhere. From the main western mass, a narrow dyke-like extension severs the pyritic quartzite (Jack's geyser overflow) between the West works and the Consolidated Mines shaft.

Quartz-felsite bounds the auriferous deposit on the east, and is seen in the river bank in that direction, where it has the appearance of being interbedded with the sedimentaries.

Through the acid intrusives and the altered sedimentary rocks (Gympie[1]) a network of later doleritic dykes penetrate in all directions, and at all angles of inclination, from nearly vertical to approximately horizontal.

It is probable that the older intrusives—quartz-felsite and hornblendic granite—were one of the original inciting causes of the metalliferous impregnation of the Mount Morgan deposit. That the latter was antecedent to the doleritic dykes, so prominent in the workings, is evident from the fact that a large block of the auriferous stone is engulfed in one of them.

David and Anderson, from petrographical examination of rock sections, regarded the doleritic dykes as probably of two ages; a prediction subsequently verified in the open-cut workings, where displacement of some dykes by others is exposed.

Though the intersecting dykes antedate the metalliferous deposit, it is highly probable that they, or rather their solfataric agencies, exerted an important influence on its silicification, kaolinisation, and subsequent enrichment. The phenomenal richness of the upper zone, however, was unquestionably due to decomposition, or oxidation, of the auriferous pyrites brought about by ordinary atmospheric agents, and subsequent leaching and redeposition of the gold in concentrated bulk by chemical action and interaction.

All gradations are visible, from the leached cellular silica (sinter of Jack) to the massive silico-pyritic ore of the lower levels; likewise all stages of the process of decomposition and removal of the investing sulphides.

It would appear from the aforegoing that the original mineralisation is of considerable age; the secondary silicification of intermediate, and the extraordinary superficial gold enrichment, comparatively recent and progressive.

The mode of occurrence of the copper is entirely in harmony with the gradation of the gold. Entirely removed from the leached cap, partially removed beneath it, and enriched by redeposition at a lower level.

If the genesis of the deposit be approximately indicated, gradual depreciation in values will be coincident with depth until the primitive zone of deposition is reached; the mining limit being the commercial.

Judging by analogy, it is probable that a zone is reached in copper lodes where values, though low, are fairly constant. Mount Morgan ore—as a smelting proposition—is decidedly silicious, but its gold values are high, which enables a considerable amount of barren ironstone and limestone flux being used at present. Utilisation of profitable pyritic flux from Many Peaks, near Gladstone, will, however, immensely increase the commercial working limit.[2]

Mount Morgan lodestuff is naturally divisible into three classes, which are treated separately:—

1. Oxidised, non-cupriferous ore—free milling. Above 300-feet level.
2. Slightly cupriferous pyritic ore—roasting and leaching. Between 300 and 650 feet level.
3. Cupriferous pyrites—smelting. Below 650-feet level.

[1] R. L. Jack. [2] Composition:—copper, 2·67; silica, 6·16; iron, 39·9; sulphur, 35·0; carbonate of lime, 5·8; alumina, 3·64 per cent.

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The first offers no special features in connection with the present work, inasmuch as its original copper contents have been entirely removed by natural processes of decomposition and leaching, the gold contents being recoverable by ordinary milling and chlorination.

The second, revealing partial impoverishment, and the third, enrichment, are of special interest.

The second, or slightly cupriferous ore, containing about 1 per cent. of copper, is treated in a separate plant—the Mundic. After grinding in ball mills, with screens of 400 holes to the inch, it is roasted in reverberatory furnaces. From the latter it passes to hoppers, from which it is charged into vats of large capacity—several holding 1,000 tons. Here it is first washed with a weak solution of sulphuric acid (waste liquor from cementation canals) to dissolve out the bulk of the copper, the cupriferous solution passing again to the cementation canals. The roasted and washed ore in the vats is treated with chlorine solution for gold recovery, a little more copper being dissolved in this process. The solution, after removal of the gold by precipitating on charcoal filters, is passed through copper-precipitating canals, brought up to proper chlorine strength, and again circulated.

The copper ore remaining in the tailings in the insoluble form of oxide gradually decomposes on exposure, and yields eventually to percolating acid solutions; these are collected in a filter dam and pumped to the precipitating canals. Throughout the entire process the acid solutions are in constant circulation.

The cement copper, amounting to about 50 tons of pure copper per month, is sieved, dried, packed in barrels, and sent to America.

The third, or direct smelting ore, has about the following average composition :—

Silica	43·5 per cent.	Gold, about 8 dwt. per ton.
Iron	23·5 ,,	
Sulphur	23·0 ,,	
Alumina	2·5 ,,	
Copper	3·8 ,,	
	96·3 ,,	

The balance being moisture and undetermined.

The ore is fluxed with limestone, iron ore, and converter slag in the following proportions :—

Auro-cupriferous pyrites	100 lb.	Weight of charge, 31 cwt.
Limestone	60 ,,	
Ironstone	20 ,,	
Converter slag	10 ,,	
Coke	8 ,,	

The limestone is brought by rail from the Mount Morgan Company's quarries at Marmor, and has the following composition :—

Carbonate of calcium	96·5
Silica	3·5
	100·00

The ironstone from the Company's mine at Iron Island, consisting of magnetite and hematite, has the following composition :—

Iron	63·0 per cent. = 81·0 FeO.
Silica	5·0 ,,

The coke contains about 15 per cent. of ash.

Instead of barren flux, it is hoped ere long to use Many Peak cupriferous pyrites, containing about 2½ per cent. of copper.

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Blast Furnaces, Mt. Morgan.

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Converters, Mount Morgan.

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The smelting plant consists of four blast-furnaces, of a capacity of about 200 tons of ore each per day. Three only, however, are kept in constant use, one being for emergency.

The matte runs about 45 per cent. in one operation. The slag runs about —silica 39, ferrous oxide 32, and lime 23·5 per cent.

The converter plant consists of nine shells of 3½ tons capacity each. The converter vessels are 8 feet by 6 feet diameter, and electrically operated.

Linings are renewed after six charges, the material being prepared of ore from the open cut, containing 88 per cent. of silica and 3½ dwt. of gold, and silicious shale from the Desert Sandstone Series (Jack) which cap the ranges in the vicinity.

Excellent fire-bricks are also manufactured from the latter, which contains about 86 per cent. of silica.

The Blister copper runs about 99·2 per cent. copper, and contains about 12 oz. of gold per ton and 2½ oz. silver.

The furnaces have circular fore-hearths 14 feet in diameter (outside measurement), and small auxiliary fore-hearths.

Double-bowl slag cars are used, each holding 1 ton.

Owing at present to insufficient elevation, the matte is conveyed in roller-bearing matte-pots by manual labour to ladle, which, when filled, is hoisted by travelling crane to converters.

The ore-bins at smelting-house consist of four rows, each containing sixteen bins; the capacity of each bin being 160 tons ore, 120 tons limestone, 320 tons ironstone, or 60 tons coke, according to the nature of the material stowed.

Total Production of Copper.

Year ended 31st May.	Yield of Copper Precipitate.	Proceeds from Copper Precipitate.	Ore Smelted.	Yield of Blister Copper.	Containing—		Proceeds from Blister Copper.
					Copper.	Gold.	
	tons.	£ s. d.	tons.	tons.	tons.	oz.	£
1902.....	25	57 7 10	.....	.....	.....	.....	.....
1903.....	106	2,672 14 0	.....	.....	.....	.....	.....
1904.....	*344	15,484 13 8	.....	.....	.....	.....	.....
1905.....	†501	25,751 11 7	.....	.....	.....	.....	.....
1906.....	389	16,375 14 8	22,153	182	179	2,700	25,500
1907.....	470	39,068 7 9	123,135	3,757	3,723	47,215	479,500
1908.....	496	17,616 10 10	163,078	5,167	5,120	67,497	532,854
	2,331	117,027 0 4	308,366	9,106	9,022	117,412	1,037,854

*This includes 157 tons of Matte, which realised £9,084 12s. 5d.
† „ „ 326 „ „ „ „ £16,713 7s. 5d.

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The following table shows the total quantity of ore chlorinated and smelted in each year since the formation of the Company in July, 1886; the total yield of gold bullion, and the proceeds of gold and copper, the expenditure, and the amount of dividends paid. The yield of auriferous blister copper and of copper precipitate is shown in the preceding table:—

Year ended 31st May.	Ore Chlorinated.	Yield of Gold.	Proceeds from Gold.	Total Proceeds.*	Expenditure.	Total Dividends Paid.
	tons.	oz. dwt.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1887.....	13,071	58,027 5	238,547 3 11	238,547 3 11	80,531 17 11	133,333 6 8
1888.....	17,241	90,623 16	374,082 18 6	374,082 18 6	156,836 0 5	200,000 0 0
1889.....	49,276	235,190 15	966,447 12 9	966,447 12 9	195,086 9 3	800,000 0 0
1890.....	76,215	258,949 18	1,066,705 6 1	1,066,705 6 1	205,287 18 8	866,666 13 4
1891.....	74,741	201,582 8	828,973 13 5	828,973 13 5	209,451 18 10	600,000 0 0
1892.....	59,789	124,296 12	504,205 8 7	504,205 8 7	188,558 2 2	300,000 0 0
1893.....	62,190	119,909 13	495,535 11 5	495,535 11 5	187,089 17 11	309,000 0 0
1894.....	65,076	118,630 14	489,001 0 10	489,001 0 10	177,288 6 6	300,000 0 0
1895.....	82,448	123,803 18	513,230 1 6	513,230 1 6	183,328 16 5	300,000 0 0
1896.....	91,597	141,148 17	578,677 12 3	578,677 12 3	239,290 3 9	300,000 0 0
1897.....	105,244	159,817 6	656,780 9 11	656,780 9 11	392,160 4 7	300,000 0 0
1898.....	153,297	172,029 6	698,172 2 6	698,172 2 6	307,083 7 7	300,000 0 0
1899.....	206,502	164,909 18	664,143 8 4	664,143 8 4	370,496 0 11	350,000 0 0
1900.....	239,276	187,352 10	748,918 19 3	748,918 19 3	356,990 8 3	350,000 0 0
1901.....	215,461	173,833 0	693,273 2 6	693,273 2 6	336,718 19 10	350,000 0 0
1902.....	213,907	147,628 4	570,337 4 6	570,394 12 4	296,560 13 6	204,166 13 4
1903.....	233,568	143,584 3	566,400 19 11	569,073 13 11	317,307 18 7	275,000 0 0
1904.....	237,461	122,251 18	467,427 19 1	482,912 12 9	326,520 6 8	150,000 0 0
1905.....	246,913	137,694 18	518,115 2 4	543,866 13 11	396,840 14 4	150,000 0 0
1906.....	243,946	125,694 9	482,801 1 5	524,676 16 1	379,280 7 0	150,000 0 0
1907.....	235,889	103,464 17	413,552 14 1	932,121 1 10	558,120 14 8	162,500 0 0
1908.....	241,239	89,611 17	359,838 2 8	910,308 13 6	631,538 18 10	237,500 0 0
Grand Totals	3,162,297	3,200,086 4	12,895,167 15 9	14,050,048 16 1	6,432,368 6 7	7,079,166 13 4
					13,889 3 3	Less Refunds Sundry Accounts.
					6,418,479 3 4	
		Cash for Sundries		8,452 14 8	244,992 16 2	Add Dividend Duty and Income Tax.
					84,764 12 0	Add Royalty.
					73,593 17 11	Add Depreciation.
				14,058,502 10 4	6,821,830 9 5	

* Includes value of copper, *vide* preceding table.

TASMANIA.

Mount Lyell Mine.—The following notes are extracted from a report made by Dr. E. D. Peters, jun., on the property of the Mount Lyell Mining and Railway Company (Ltd.) in 1893.

Dr. Peters' theory of the formation of the immense pyrites deposit of Mount Lyell is that the pyrites particles containing valuable metals, originally sparingly distributed through the older Silurian stratified rocks, gradually decomposed, and were carried away in solution by waters flowing into a lagoon or bog-hole. In contact with the organic acids always present in swampy waters, the metals were precipitated in the state that they were originally in the rock, but in a massive, concentrated form. In time the pyrites filled the swamp-hole, and gradually became covered to a depth of hundreds of feet by the pebbles, sand, and mud forming the new overlying conglomerates, slates, and schists. Subsequently the whole series became elevated and tilted into its present position.

According to this theory, the present width (300 feet) of the lode represents the depth of the original swamp-hole, and the direction of the present depth its longitudinal extension.

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Mount Lyell is specially favoured by an abundant and easily-available water-power. Though the lode is a low-grade proposition, viewed as a whole, yet exceedingly rich bunches of ore occur, particularly closely adjacent to the mass of ironstone (resulting from decomposition of pyrites) on the foot-wall side, yielding over 1,000 oz. of silver per ton and 20 per cent. of copper. The width of the lode at the time of the report was 300 feet, and the walls were diverging. Its length, so far traced, is 960 feet. The composition of the average ore, according to Dr. Peters, is as follows :—

Iron pyrites	83 per cent.
Copper pyrites	14 ,,
Heavy spar	2 ,,
Silica	1 ,,
	100 ,,

The average contents in valuable metals being :—

Copper	4·5 per cent.
Silver	3 oz. per ton.
Gold	2·5 dwt. per ton.

The freedom of the ore from silica is most remarkable. It contains from 45 to 50 per cent. of sulphur (33 per cent. is sufficient for pyritic smelting); 20 per cent. of quartzose flux is required for blast-furnace treatment.

Pyritic smelting was adopted at Mount Lyell, and soon the original breaking and roasting portion of the metallurgical scheme was abandoned, the ore being so suitable for the pyritic process that no preliminary treatment is found necessary. Just as it comes from the faces it is fed into the furnaces with about 1¼ per cent. of carbonaceous fuel. The almost pure pyritic smelting now in progress is largely quoted by Dr. Peters from data supplied by the General Manager, Mr. R. C. Sticht.[1]

Mount Lyell has been most recently described by Professor J. W. Gregory, F.R.S. From his work[2] the following extracts are taken :—

Page 85.—"The ore deposits of Mount Lyell consist of two types—(1) Mineralised bands of schist, and (2) great lens-shaped masses of very pure sulphide ores. Bands of pyritiferous quartzite also occur in the conglomerate series, and may be regarded as of similar origin to the bands of mineralised schist, but only the latter contain sufficient ore to be of any economic importance.

"The minerals which occur in the bands of mineralised schist are chiefly iron pyrites and fahlore, associated with copper pyrites and bornite. These minerals are in places loosely disseminated through the ordinary schist; elsewhere they occur in the silicious schists, forming acid copper ores, and some bands of low-grade material that has hitherto only proved of value as a flux in smelting the pure pyritic ores of the great ore bodies."

Page 90.—"The great masses of sulphide ores are the source of the wealth of the Mount Lyell field. There are two main ore bodies. The largest is that of the Mount Lyell Mining and Railway Company, known as the "Big Mine," or "Parent Mine," and as the "Iron Blow." . . . . The ore body trends N.W. by W., and its length on the surface was 800 feet, and its width 200 feet. It is worked by an open cut in a series of nine terraces or benches.

"It is irregularly boat-shaped in form, consisting of an elliptical mass, which tapers gradually downward, and is then cut off below with a rounded base." (At a depth of about 700 feet.)

"The ores in this body are of remarkable purity and uniformity. Peters remarked that in a width of 300 feet across the mass 'in the entire distance, there is not a piece of gangue rock as large as a walnut' (p. 10). The ores

[1] Principles of Copper-smelting, 1907.
[2] The Mt. Lyell Mining Field, Tasmania.—Austr. Inst. Mining Engineers, 1905.

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consist almost entirely of iron pyrites, containing copper, gold, and silver. There is a little galena and less sphalerite (zinc-blende). The only two important minerals forming gangue are quartz and barite.

"The average composition of the ore which it pays to extract is :—

Iron	40·30
Silica	4·42
Barium sulphate	2·50
Copper	2·35
Alumina	2·04
Sulphur	46·50

"The mine is by no means equally rich throughout, for the ore on the hanging-wall side contains less copper and precious metals than on the eastern or footwall side, and the ore is also, as a rule, richer near the surface than at the deeper levels.

"Some masses of rich ore occur in the ore mass, but most of them have already been removed by underground excavation. These ores are silicious, and the copper-bearing minerals they contain are bornite and chalcopyrite. The average analysis of these ores is as follows :—

Iron	24·75
Silica	30·69
Barium sulphate	1·48
Copper	5·33
Alumina	6·30
Sulphur	30·00

Page 98.—"More important shoots of the richer ores have been found on the footwall side of the mine. The largest, known as the Mount Lyell Bonanza, was discovered, and worked out in 1894; it yielded 850 tons of ore, which was sent to London and sold for £105,000. . . . It consisted of a vein of copper glance (redruthite, Cu_2S) and bornite, with fahlore and argentite (silver glance Ag_2S). The entire shipment averaged 1,011 oz. of silver per ton."

Page 101.—"Actual work has proved that the average of the ore used up to the end of September, 1902 = 1,320,134 tons smelted—yielded an assay value of copper, 2·92 per cent., silver, 2·74 oz., and gold, 1·94 dwt. per ton."

The silicious flux ore from the Royal Tharsis Mine is given as :—

Copper	1·68 per cent.
Silver	·24 oz. per ton.
Gold	·026 „ „

The Mount Lyell Mine was subsequently amalgamated with the North Mount Lyell, Lyell Tharsis, South Tharsis, and Royal Tharsis Mines, worked by the Mount Lyell Mining and Railway Company, incorporated 11th August, 1903.

The magnitude of this Company's operations may be seen from the following extracts from its report for the half-year ending 31st March, 1908 :—

"The average assay value of the half-year's output from the Mount Lyell Mine—139,691 tons—was :—

Copper	0·87 per cent.	
Silver	1·90 oz.	per ton.
Gold	0·069 oz.	

"From the North Mount Lyell, the assay value of the output of 63,250 tons was :—

Copper	5·94 per cent.	
Silver	1·49 oz.	per ton.
Gold	0·004 oz.	

"Composition of North Mount Lyell, Lyell Tharsis, and South Tharsis, metal-bearing fluxes :—

Copper	1·21 per cent.	
Silver	0·33 oz.	per ton.
Gold	trace	

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The Mount Lyell ore was raised from the open cut, and no new developments in depth were proved. In the North Mount Lyell, however, the ore bodies at 850-feet level were traced down to the 1,000 feet.

Ore Reserves.—The reserves estimated as available in the above two mines at the end of March, 1908, are as follows :—

	Tons.	Copper.	Assay. Silver.	Gold.
		per cent.	oz.	oz.
Mount Lyell Mine—				
Available for open-cut excavation	909,471	0·60	1·93	0·043
,, underground ,,	2,613,945	0·52	1·97	0·025
Total	3,523,416	0·54	1·96	0·030
North Mount Lyell Mine (including Lyell Tharsis Mine)	606,658	5·75	1·33	0·005

Smelting results since 10th August, 1903, are as follows :—

	Treated Dry Weight.	Average Assay.		
		Copper.	Silver.	Gold.
	tons.	per cent.	oz.	oz.
Mount Lyell Mine—aggregate	1,329,091	0·92	1·90	0·071
North Mount Lyell (including Lyell Tharsis)—aggregate	518,104	6·06	1·76	0·005
South Tharsis, Royal Tharsis, North Mount Lyell, Lyell Tharsis (Silicious metal-bearing fluxes.)—aggregate	56,052	1·49	0·39	0·0018

	Matte treated.	Blister Copper produced.	Average Assay.		
			Copper.	Silver.	Gold.
	tons.	tons.	per cent.	per ton. oz.	per ton. oz.
Products—					
Since 10th August, 1903	111,580	38,927	98·79	87·36	2·628

	Copper.	Silver.	Gold.
	tons.	oz.	oz.
Total Metal Output—			
Produced by former Mount Lyell Mining and Railway Company, Ltd.	48,577	4,121,401	155,752
Produced by present Company from 11th August, 1903, to 31st March, 1908	38,457	3,400,840	102,304
*Total Output	87,034	7,522,241	258,056

* These figures do not include the output from the North Mount Lyell Mine prior to 11th August, 1903, such not being obtainable.

Dividends and Bonuses.—Former Company paid £996,574 9s. 8d. ; present Company, from 11th August, 1903, to 31st March, 1908, £1,020,000 ; total dividends and bonuses, £2,016,574 9s. 8d.

Smelting Plant.—Six furnaces running, four on full time ; number of men employed—Mines, 800 ; reduction works, 875 ; railway, 170 ; total, 1,845.

Working costs per ton of ore treated, half-year ending 31st March, 1908 :—Mining, 6s. 4·35d. ; smelting, 7s. 9·60d. ; Bessemerizing, 1s. 2·44d. ; total, 15s. 4·39d.

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Mansfeld Copper Deposit, Harz, Germany.

According to the authority quoted by J. A. Phillips and H. Louis[1]—"Der Kupfershieferbergbau und der Hüttenbetrieb zur Vararbeitung der gewonnen Minern 1881,"—mining was commenced in the County of Mansfeld, on the southern declivity of the Harz, in the year 1199, and has, with but little interruption, continued flourishing up to the present time.

"In 1852 the various companies interested were consolidated into one (the Mansfelder Kupferschieferbauende Gewerkschaft) for working the Mansfeld copper schist, which produces annually about 15,000 tons of copper, together with 75 tons of silver; and affords employment to nearly 13,000 miners. This was the first place where steam-power was applied to mining, in 1785, a Watts fire-engine being imported from England to keep down the water by driving the pumps in place of horse-power."

The strata of the Mansfeld copper district "form a comparatively regular basin, round the edge of which the copper schist crops out for the greater part of its circumference; its width is about 11 miles and its area about 193 square miles. Most of the present workings are restricted to the northern and western sides of the basin, where the copper schist occurs with a flat dip of from 5° to 8° over a length of about 14 miles."

"The bituminous marl constituting the copper schist, or copper shale, lies everywhere with the greatest regularity on the *Rothliegendes* [the formation forming the base of the Kupferschiefer or copper schist.—J.E.C.], so that it can be followed as a thin black band. [About 19 inches in thickness.—J.E.C.]

"The metalliferous contents of the Kupferschiefer seam occur, as a rule, in the form of *Speise*—that is, sprinkled in the form of a very fine dust, which, on a transverse fracture, causes a metallic reflection in sunlight. It has either a golden colour from the presence of copper pyrites in predominant quantity, or a violet, blue, and copper-red colour from the presence of erubescite; more rarely the colour is steel-grey from copper glance, or greyish-yellow from iron pyrites, and finally sometimes bluish-grey from the presence of galena. Although the speise principally consists of sulphuretted ores of copper, there also occur, in greater or less quantities not visible to the eye, sulphide of silver, blende, galena, iron and copper pyrites, copper nickel, and arsenical cobalt, as well as compounds of manganese, molybdenum, and selenium; oxidised compounds and salts also occur as secondary products.

"The term *Flotz* (seam) is usually applied to the productive bed only, the thickness of which varies from 2½ to 5 inches."

The roof being softer than the floor is removed to a height of 16 to 22 inches, sufficient only to allow of the width of the workman's shoulders as they work reclining.

The following analysis of the copper shale in 1879 is taken from the work quoted for comparison with that given by Professor David from the cupriferous shales of the Triassic Series of this State:—

Analysis of the Mansfeld Kupferschiefer (average from three shafts).

Silica	33·59
Alumina	13·53
Lime	12·66
Magnesia	2·70
Carbonic acid	8·97
Iron	2·69
Copper	2·59
Silver	0·017
Sulphur	3·43
Bitumen by loss	13·91

The Kupferschiefer of the Mansfeld District contains on an average from 2 to 3 per cent. of copper, with about 10 lb. of silver to the ton of copper.

(Zinc, lead, manganese, nickel, and cobalt not quantitatively estimated.)

[1] J. A. Phillips and H. Louis. A Treatise on Ore Deposits, 1896, pp. 395-404.

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Spain.

Rio Tinto and Tharsis Pyrites Deposits.—The following description of the Rio Tinto Deposits, by J. A. Phillips and Henry Louis,[1] applies closely to both mines:—"These deposits of cupriferous pyrites consist of a series of more or less continuous lenticular masses running parallel with the bedding of the enclosing slate, sometimes extending to a great length, occasionally having a width exceeding 50 fathoms, and composed of an intimate admixture of iron pyrites with a little copper pyrites, through which strings of the latter mineral sometimes ramify. Small strings of black sulphide of copper less frequently traverse the mass.

"The deposits are developed in the immediate neighbourhood of a series of dykes of porphyry that traverse the stratified rocks, and with the presence of which that of the deposits is evidently very closely connected.

"The Rio Tinto Company's property is situated in the Province of Huelva, in the south of Spain. The amount of ore extracted in 1907 reached 1,906,948 tons, averaging 2·81 per cent. of copper. The Company possesses immense deposits of low-grade pyrites, and it is estimated that at the present rate of production—as above—it has seventy years output in sight.

"About 200,000 tons only can be calcined at the mines annually under the terms of concession. About 550,000 tons are exported; the remainder is thrown on the reserve heaps, where it is spread over a large surface and drenched with water. This and the rainfall leaches out the soluble copper sulphate produced by oxidation or decomposition of the pyrites. The cupriferous solution is collected in pools and the copper precipitated with scrap-iron."

"Wet Methods of Extracting Copper at Rio Tinto, Spain.[2]

"By Charles H. Jones, Santiago de Cuba.

"The ore treated at Rio Tinto is a massive iron pyrites containing up to 3 per cent. of copper, which has been disseminated through the mass by a secondary enrichment.

"The well-known method adopted for the extraction of the copper consists simply in allowing huge heaps of the mineral to oxidise under the influence of moisture and air, and subsequently washing out the copper sulphate as soon as it is formed, by running water through the heap.

"At the outset it may be well to have it clearly understood that the successful and economical application of this system depends largely on the state in which the copper occurs in the mineral. If it exists as chalcopyrite, $CuFeS_2$, the copper will not oxidise by simple exposure to the air, in one case it having taken many years to oxidise 10 per cent. of the copper originally present in the ore. If the copper is in the form of CuS, the oxidation proceeds very slowly. The best form for solution is Cu_2S, or copper glance, which constitutes the bulk of the copper in Rio Tinto pyrites. These statements may be made clearer from the following account of the reactions that take place during the oxidation.

"When the mineral is exposed to free access of air and moisture, some ferrous sulphate is formed in accordance with the following reaction:—

(1) $FeS_2 + 7O + H_2O = FeSO_4 + H_2SO_4$.

This ferrous sulphate becomes readily oxidised by the air to ferric sulphate.

(2) $2\ FeSO_4 + H_2SO_4 + O = Fe_2(SO_4)_3 + H_2O$,

[1] A Treatise on Ore Deposits, 1896, pp. 499–500.
[2] Trans. Amalgamated Inst. Mining Engineers, XXXV, 1905, pp. 8–11.

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and it is due to the action of this ferric sulphate on the copper sulphides that the copper is rendered soluble, as is shown by the following chemical equations :—

(3) $Fe_2(SO_4)_3 + Cu_2S = CuSO_4 + 2FeSO_4 + CuS$.

(4) $Fe_2(SO_4)_3 + CuS + 3O + H_2O = CuSO_4 + 2FeSO_4 + H_2SO_4$.

The reaction No. 3 takes place fairly rapidly and causes half the copper to go into solution within a few months, while the reaction No. 4 proceeds much more slowly, and requires, under the most favourable conditions, about two years to extract 80 per cent. of the remaining half of the copper.

" Here I may add that in the laboratory at Rio Tinto (under the direction of Mr. W. A. Jenkin), a method has been worked out to determine the state of combination of the copper in any particular mineral. This method depends on the action of the mineral on various solutions under constant conditions of dilution and temperature, and, though necessarily somewhat arbitrary, it shows with considerable accuracy the form of sulphide in which the copper exists, and consequently whether the copper can be readily extracted by washing in heaps.

" In practice the method adopted to bring about the desired oxidation is as follows : A site is chosen for the formation of the heap where the ground is sufficiently concave and sloping to enable the copper liquor that is formed to collect and run out at the base of the heap. On the ground is first arranged a network of air-flues, made of rough stones and having an internal diameter of 12 inches. Vertical chimneys, 50 feet distant from one another, are built in the same manner and connect with the ground-flues. Care is taken that the mouths of the ground-flues are kept open and not covered by the ore. The mineral, the lump portion of which has been passed through jaw-breakers to be reduced to pieces not larger than from 2 to 3 inches across, is now tipped from side-tip waggons at the highest part of the selected site over and around the stone-flues. 'Lump' and 'fines' are alternately dumped until the height of the mass at the edge is about 30 feet, the upper surface of the mineral being kept level. A heap of this form approximately contains 100,000 tons of ore.

" As the mineral is added, the building of the stone chimneys keeps pace, in order to have a clear opening to the top of the heap. The surface of the heap is formed into squares by means of ridges of the mineral, the size of these squares depending on the porosity of the heap. The function of these ridges is to enable the water to be run on locally over the surface of the heap in order to insure that all parts are equally washed and that the water does not run through the heap in channels. A system of gutters is also arranged so that the water can be run on to all part of the mass. As the heap is being formed water is run on, and the copper sulphate existing in the mineral is extracted ; the water also provides the moisture necessary for the oxidation in accordance with the equations given above. The mineral in the heap is then allowed to oxidize, which it does pretty rapidly, as evidenced by the heat produced, the temperature in the chimneys rising to from 170 degrees to 180 degrees F. As the temperature increases, the surface openings of the chimneys may be closed in order to allow the oxidation to spread through the heap. The surface gradually shows a brownish colouration due to the dehydration of the buff-coloured basic ferric salt that forms on the top of the mass, and its gradual heating-up may be noted by this drying action. The greatest care must be taken not to allow the heap to fire, for a fire once started is very difficult to extinguish. When the oxidation has proceeded as far as it is safe to allow it, water is run on at the rate of about 50 cubic metres per hour, until the soluble copper is leached out ; the heap is then allowed to reoxidize and the washing is repeated. After about a year has elapsed the surface requires

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"retilling," and the squares are rearranged so that the places where the ridges were before are now the middles of the squares; the gutters also are shifted. At the edge of the heap, for a distance of some yards, the mineral, which has become cemented, holds a considerable quantity of copper salts and is dug down into terraces in order that this copper may be extracted by washing. When the copper is reduced to 0·3 per cent. the heap is considered washed, and the mineral, containing 49·5 per cent. of sulphur, is removed and exported as 'washed sulphur-ore,' and utilised for the manufacture of sulphuric acid.

"Successful heap-washing depends on the efficient ventilation of the mass, the trouble usually being a too great excess of 'fines' produced in mining the ore, which cement hard and clog up the air passages.

"The copper liquor, as it runs from the heap, contains some ferric iron in solution, which, as will be shown later, is very objectionable. In order to remove the ferric iron, the liquor is run over a smaller heap of fresh mineral, known as a 'filter bed,' which reduces the ferric iron. This 'bed' is laid inside a reservoir formed by a masonry dam across a small ravine, and the liquor, after percolating through the mineral, remains in contact with it until it is required to be drawn off to the precipitating tanks. When the mineral is fresh, the reduction of the ferric iron takes place rapidly, due to the Cu_2S, as shown by equation 3; but the iron pyrites itself has an effective reduction action on ferric iron in solution according to the following equation:

(5) $7Fe_2(SO_4)_3 + FeS_2 + 8H_2O = 15FeSO_4 + 8H_2SO_4$.

"The principal constituents of the liquor as it enters the cementation tanks are as follows, the figures given representing the grammes per cubic metre or units per million parts:—Copper, 4,000; ferric iron, 1,000; ferrous iron, 20,000; free sulphuric acid, 10,000; and arsenic, 300. The large quantities of ferrous iron and free sulphuric acid present are due to the fact that the waste liquor from the cementation tanks, after the copper has been precipitated ('salida' liquor, as it is called), is pumped back and used for washing the heaps, in addition to fresh water, and consequently these solutions tend to become concentrated. The liquor is then run from the reservoirs at about 300 cubic metres per hour through the precipitation tanks over pig iron, in order to precipitate the copper in the form of so-called 'cement copper' or 'copper precipitate.' These cementation tanks are arranged in series on the slope of a hill, the liquor passing backwards and forwards until it is discharged from the lowest tank of the series free from copper.

"Each series consists of three tanks in parallel, arranged so that the liquor can be divided up and passed along as many tanks as necessary, depending on the quantity of liquor that is being run through and on the varying temperature of the liquor with different seasons; the hotter the solution, which in summer reaches 100 degrees F., the faster the rate of precipitation. Each tank is about 320 feet long, 5·5 feet wide, and 2·25 feet deep, and has a slope varying from 2 per 1,000 in the first series to 11 per 1,000 in the last, the reason for the increase in slope being that as the liquor becomes impoverished in copper, the free acid present is more active in wastefully dissolving the pig-iron—an action which is considerably diminished by increasing the velocity of the liquor by means of the increased slope of the tanks. The tanks themselves are made of 9 inch by 3 inch boards, attached to wooden frames, set in cement, the space between parallel tanks being filled in with stone and cement, constituting a wall supporting the sides of the tanks.

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"No metal is used in the construction, hard wooden pegs being employed to attach the boards to the frames. The spaces between the boards are carefully caulked with oakum and pitch, in order to render the tank water-tight. At each end of the tank is an arrangement by which a door can be dropped in and luted so as to cut out that particular tank, and there are also wooden plugs that can be removed, so that the liquor from that tank can be run off, thus allowing for the removal of the precipitated copper. A few old boards are placed on the bottom of the tanks for their protection, and on these are piled up the pigs of iron, which are laid across the tank at the bottom, the next layer being at right-angles to the first, and so on, until the tank is filled; each foot-length of the tank contains about 1 ton of iron. The liquor is allowed to run through the system of tanks, and needs no attention, except to remove the precipitated copper and to add fresh iron. The 'salida' liquor, containing from 15 to 20 grammes of copper per cubic metre, is allowed to run to waste, for the reason that with this copper-content the amount of iron required to precipitate the copper equals the value of the copper recovered. Daily some of the tanks are cleaned out by being closed as described above, the liquor meanwhile passing down the other tanks of the series; the liquor is run off into settling tanks, and copper in suspension being there recovered. All of the iron is removed from the tank and piled on to the dividing wall; at the same time the copper adhering to the iron is knocked off and thrown back into the tank. The dirty looking precipitate is then transferred to the cleaning and concentrating plant, the iron is replaced in the tank, and the liquor again allowed to run through it. This crude precipitate, containing about 70 per cent. of copper, is thrown a little at a time on to a perforated copper plate placed at the head of a long launder or tank, and is washed through the plate by a strong stream of water from a small nozzle. The material that does not pass through the screen consists of leaf-copper and small pieces of iron; this material is thrown into a heap, and afterwards sorted over by girls, who remove the pieces of iron. The precipitate that passes into the launder is repeatedly turned over against the stream of water, and by this simple means a concentration is effected

"The first few yards of the launder contain a red precipitate known as 'No. 1 precipitate,' containing 94 per cent. of copper and less than 0·3 per cent. of arsenic; following this is 'No. 2 precipitate,' containing 92 per cent. of copper and 5 per cent. of arsenic, while below is the 'No. 3 precipitate'; this is in a state of very fine division, and contains on an average 50 per cent. of copper and 5 per cent. of arsenic. This last-named portion, which carries all the graphite from the pig, contains the bulk of the antimony and bismuth that is also precipitated from the liquors. Classes Nos. 1 and 2 are removed to the drying sheds, and are bagged for shipment to the refinery; the No. 3 precipitate is removed, moistened with acid liquors, made into balls by hand and dried in the sun. These balls become cemented hard and can be readily transferred to the smelter, where they form part of the charge for the blast furnaces and are run down to matte to be subsequently bessemerized, thus effectively removing the arsenic, antimony, and bismuth that they contain.

"The reactions that take place in the cementation tanks are given in equations 6, 7, and 8.

"The first reaction that occurs in the liquor running over metallic iron is the reduction of the ferric sulphate to ferrous sulphate, the final result being in accordance with the equation :—

(6) $Fe_2(SO_4)_3 + Fe = 3FeSO_4$.

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This action causes the consumption of the pig-iron without any corresponding yield in copper, and, consequently, should be avoided as far as possible by having all the iron in the ferrous state.

"The second reaction is the precipitation of the metallic copper, brought about by galvanic action. The iron becomes coated with copper, and thus the iron and copper in the acid liquor constitute a galvanic couple with a considerable difference of potential. It is due to the electrolytic action that the copper, and all other metals present that are electro-negative to iron, will be precipitated. The ultimate action of the precipitation may be chemically expressed by the following equation:—

(7) $Fe + CuSO_4 = FeSO_4 + Cu.$

Besides the reactions above mentioned, there is one that causes the liberation of hydrogen, as evidenced by the bubbles of gas that may be observed to arise in the tank liquor. This action, which causes a wasteful consumption of the iron, may be expressed as a final result by the following equation:—

(8) $Fe + H_2SO_4 = FeSO_4 + H_2.$

"These three equations constitute the main reactions that take place in the precipitating tanks.

"While the liquor is fairly strong in copper, the copper is mostly precipitated in a coherent form; but in the later stages as the liquor becomes impoverished it is precipitated in a powdery state—a condition which is more effective in its galvanic action with the iron, and thus unfortunately causes a larger precipitation of arsenic and other impurities than in the earlier stages. In the later stages, also, the 'solution reaction' of iron in sulphuric acid, as given in reaction No. 8, goes on to a proportionately greater extent than does the precipitation of copper, and, consequently, the cost of pig-iron in precipitating the copper varies inversely as the quantity of copper in the liquor.

"By keeping careful watch on the reduction as far as possible of the ferric iron before the liquor enters the tanks, and by giving it sufficient velocity through the tanks, a strongly acid liquor, such as given above, during a year's working will not consume more than 1·4 units of pig-iron (containing 92 per cent. of iron) to 1 unit of copper precipitated. A valuable check on the iron being consumed can easily be kept by the laboratory by analyzing the liquors before entering and after leaving the tanks, and from these analyses the quantity of iron that is being consumed can be calculated."

United States.

Lake Superior and Montana Copper Deposits.

The Lake Superior copper deposits consist of two lava-flows with interbedded conglomerates. Dr. M. E. Wadsworth, President of the Michigan College of Mines, Houghton, Michigan, states[1] that the copper deposits occur as—

"1. Vein-deposits (fissure veins).
"2. Flow-deposits (melaphyrs or amygdaloids).
"3. Bed-deposits (conglomerates).

"In the veins the copper is found intimately mixed with the gangue, or in sheets or irregular masses. In sheet form the copper extends downward, or has its sides approximately parallel with the vein. Often the vein is divided, and holds between its parts some of the gangue or melaphyr. . . . The

[1] "The Origin and Mode of Occurrence of the Lake Superior Copper Deposits." Trans. American Inst. Mining Engineers, 1893, XXVI, pp. 667–696.

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melaphyrs themselves are often impregnated with copper adjacent to the veins. Good illustrations of the veins can be seen at the Phœnix, Cliff, Central Copper Falls, and other mines in Keweenaw County.

"In the vicinity of Hancock, Houghton, and Opechee some of the old lavas are mined. As stated before, these old lava-flows which now form melaphyrs (amygdaloids) have been greatly acted upon by water, and have had deposited in their mass different minerals associated with more or less copper. The copper is generally deposited in an irregular manner in the melaphyr, forming strings, globules, irregular masses, &c. These deposits are not in the form of veins, but are impregnations of old lava flows, and hence, are in the form of beds. As an example of mines worked upon these old lava-flows, there may be cited the Quincy, Franklin, Osceola, Atlantic, Huron, and the Copper Falls in part. . . .

"Besides the veins and lava-flows, the conglomerates have also been found in places to have had their interstices filled in with copper and other minerals. In them the old cementing mud, and oftentimes the pebbles of melaphyr, have been removed by percolating waters, and their places filled with copper, which penetrates even the minute cracks in the hard rhyolite (quartz porphyry) pebbles. These old sea-beach conglomerates are now worked in the Calumet and Hecla, the Tamarack, the Allouez, and other mines.

"The conglomerates are known to be old sea-beach deposits, like those that are now forming along the lake or ocean at the present time. This is proved by the rounded and waterworn character of their pebbles and grains; by the observed water-action on the surface of the underlying lava-flow; and by the fact that at their base the conglomerates contain considerable basaltic mud and pebbles derived from the underlying lava, both of which diminish in amount or are entirely wanting as the distance from the underlying trap increases.

"That the copper was deposited from water, with or without electro-chemical action, is shown by the fact of its being found enclosed entirely in minerals known to be formed by water only; also by its enclosing such minerals; by its being found in disconnected or isolated masses in the lavas and elsewhere; and by its greater abundance where there are to be seen the most signs of water-action. Had the copper been deposited by igneous agencies subsequently to the formation of the melaphyr and conglomerates it would have had a channel or line of passage, and would have been continuous along that line, so that all the different masses of copper would have been connected downwards, unless separated by fractures or faults. . . . From the fact that the copper is generally found most abundantly under the heavy lava-flows, and associated with minerals evidently the product of the decomposed lava, it appears probable that the copper was once finely disseminated through the lavas, and has since been concentrated by waters percolating through them. This view is advocated by Müller, Bauermann, Marvine, and myself, while a similar view has been advanced by S. F. Emmons to account for the origin and concentration of the Leadville ore-deposits.

"That the copper ore was deposited after the copper-bearing series was complete, is shown by the fact that it is found in fissures extending across the beds that could only have been produced after the beds were in place; by the fact that the copper was deposited subsequently to the jointing of the lavas, owing to its now being found wrapped around pieces formed by jointing; and by the extension of the copper from one flow down into another as a continuous mass.

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"The means by which the copper was concentrated and deposited as native copper, instead of occurring in the form of the usual copper ores, is an interesting and, as yet, unsolved problem. . . . .

"The structure of Keweenaw Point may then be summarised as follows :— A deposit of sandstone overlain by lava-flows mingled with more or less of interbedded conglomerates, and finally overlain by sandstones. Subsequently, these beds suffered longitudinal and cross fracturing and faulting. Later, all were acted upon by percolating waters—both hot and cold—by which the rocks were altered to a greater or less extent, and the copper was concentrated and stored up in the conglomerates, lavas, and veins, in which it is now found."

The greater proportion of the Lake Superior copper comes from the conglomerate beds, which, according to Dr. Peters,[1] in 1893, amounted to 75 per cent. of an output of 85,662,000 lb. (38,241½ tons). This large proportion comes from an ore chute about 3 miles in length, and penetrated to 8,290 feet in depth, worked by the Calumet and Hecla, Tamarack, and Atlantic Mines. Dividends paid by the first-mentioned mine to the end of 1905, amounted to $92,850,000, equal to over £18,570,000.[2]

The grade of the ore is stated to range from ¾ to 1 per cent. of copper to about 1½ per cent., save in the case of the Calumet and Hecla, whose early richness, 4½ per cent., made it an extraordinary exception.[3] The average contents of the ores now mined at Lake Superior may be placed at about 2·9 per cent. or less. The output has greatly increased of late years; the Calumet and Hecla alone produced 95,100,610 lb. of fine copper in 1905 (according to Stevens, *Ibid.*); equal to 42,455·6 tons.[4]

It must be pointed out with reference to the successful exploitation of these low-grade deposits that the copper of Lake Superior occurs in the metallic state, which obviates the costly processes of roasting and smelting. Simple concentration alone being requisite to prepare the metal for a simple fusion and refining process. The remarkable freedom of the native metal of this region from deleterious impurities renders it naturally of the highest market grade.

Copper Lodes of Butte City, Montana, U.S.

The following description of the occurrence of the Butte lodes is extracted from a paper from Dr. E. D. Peters, junior.[5] The metalliferous area of interest to miners is enclosed within a rectangle of 2½ miles by one mile. The lodes are described as true fissures in granite, in which felspar is limited :—

"The copper lodes usually appear on the surface as wide bands of quartzose rock, much decomposed and heavily stained with oxides of iron. Carbonates and oxides of copper mostly appear only as stains, so that, as will be seen, there being little indication of the immense value below. This surface ore invariably carries silver, generally in a free milling condition, and in most of the larger veins in sufficient quantities to pay for treatment. In fact, nearly all the mines that are now considered distinctly as copper lodes were first treated exclusively as silver properties—assaying from 10 to 60 oz. per ton, and averaging, perhaps, 20 oz. Perhaps the most noticeable feature of the Butte copper veins is their great size and remarkable continuity."

In the ninth edition of his work,[6] Dr. Peters gives the following description of these important lodes :—

"The ore occurs in irregular lodes in the granite, having an east and west strike, and an average dip of some 12 degrees to the south from the vertical,

[1] Modern Copper Smelting, 9th ed., 1898, p. 17. [2] Stevens—Copper Handbook, 1906, p. 309.
[3] *Ibid.*, 5th ed., p. 9. [4] *Ibid.*, 9th ed., 1898, p. 17. [5] U.S. Geol. Survey, Mineral Resources, 1883-84, pp. 374-396. [6] Modern Copper Smelting, 1898, pp. 19-21.

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though in places this becomes as much as 45 degrees. The distribution of the ore is also very irregular, extensive bodies of the same being frequently found on breaking through what appears to be a well-defined wall. Again, there will be no definite line between the vein and the adjacent country rock. [These features are common also to several New South Wales lodes.—J.E.C.] The ore is usually found in chutes that often extend for several hundred feet along the strike before pinching out. Their depth is frequently even greater than their length, though they are sometimes broken by small faults.

"The veins are rarely banded, and vary in size from a few inches of compact ore up to 100 feet or more, as in the Anaconda Mine. Five or six feet may be regarded as the ordinary width, though a large proportion of the ore raised in Butte comes from stopes of much greater width than this. The gangue rock is usually granular and silicious, but not quartzose.

"The croppings of the copper veins are moderately prominent, and consist of the usual brownish iron-stained quartz that may be found at almost any point in the great American Mountain Chain [Rocky Mountains and Andes.—J.E.C.] from Alaska to Patagonia. Just below the surface, red and yellow oxides of iron appear, carrying high values in silver and gold, but usually low in copper.

"These decomposed ores extend to the water-level, which is reached at a depth of from 40 to 300 feet, depending upon the surface irregularities. At this point begins the zone of rich secondary copper ores that have made Butte famous. The copper minerals of this zone are difficult to determine, as they pass through all gradations from pure chalcocite down to chalcopyrite, bornite being also of very frequent occurrence. Iron pyrites is usually present in considerable amounts.

"Naturally, these rich, secondary ores have fallen off in depth, Ledoux estimating their average decline at 2 per cent. copper per 100 feet. But this diminution lessens as greater depth is gained, and the ore raised from the Butte mines at present, omitting a few bonanza bodies, averages about 6½ per cent. of copper and 5 oz. of silver to the ton of 2,000 lb. (0·017 per cent. silver). There is a loss of some 18 per cent. in concentration, and to this must be added the smelting loss, which will reduce the yield of the great bulk of the Butte ores to 5 per cent. copper and 4 oz. (0·014 per cent.) silver.

"Notwithstanding this great decline in percentage and values (which, to be sure, has resulted partly from the ability to work lower-grade ores to advantage) the Butte mines are making more profit to day from a 6 per cent. ore than formerly from one of double this richness. This results from the consolidation of mining properties, and from the astounding and radical improvements made in the metallurgical treatment of the ore. The rich surface ores of the district have furnished the capital that was needed to design and construct the improved plants, and to gain experience necessary for treating the lower grade ores at a profit."

Below the rich secondary ores of Butte the ordinary yellow sulphide—chalcopyrite—has made its appearance. The grade of the ore sent to the Anaconda Company's smelters in 1898 equalled 4·26 per cent. of copper and 3·48 oz. of silver and 0·01 oz. of gold per ton.[1] For later yields see footnote [2].

The following notes made during a visit of inspection to the Butte mines by the Writer in January, 1894, will perhaps be of interest.

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[1] Mineral Industry, 1899, VII, p. 209.

[2] In 1905 the averages are given by Stevens as:—copper, 3·25 per cent.; silver, 3 oz., per ton; and gold to the value of $1·75 to $2 per ton.—Copper Handbook, 1906, p. 195.

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Montana Ore-producing Company.

Average value of ores about 7 per cent. copper, concentrated through sizing machines and Harz jigs, calcined in O'Hara roasting furnaces, about 3 to 6 per cent. sulphur remaining in roast. Fed in charges of 8,000 lb. into reverberatory furnaces; product—matte containing 55 per cent. copper. Matte bessemerised in converters in 3,000 to 8,000 lb. charges; brought up to 99—99·8 per cent. blister copper in from twenty to eighty minutes.

Butte and Boston Smelting Company.

Best ore from mine sent direct to smelters, other ore concentrated by Harz jigs and Frue vanners, and roasted in O'Hara roasting furnaces in preference to revolving cylindrical furnaces; smelting by water-jacket blast furnace and reverberatories, former preferred. No flux used; one consists of bornite, enargite, and pyrite, containing over 40 per cent. of sulphur. Basic slag formed. Matte sent to Great Falls for further treatment, where water-power is available. Copper refined by electrolysis.

The Parrott Smelting Works, Butte.

Ore, consisting of bornite and pyrite, averages about 4½ per cent. of copper. Part roasted in stalls; concentrates from Harz jigs and Frue vanners roasted in an improved Spence furnace. No fuel used after first firing, the sulphur in the ore forming the combustible.

The improved roasting plant consists of two furnaces built side by side, each containing six hearths, one above the other; between them is an iron framework with carriers running on rails, each being level with a hearth. The carriers are worked by a hydraulic press and belting on narrow drums. The carriers are fitted with rakes or ploughs extending into each furnace, which, as they travel in one direction, turn the ore on the hearths, and then return and take a fresh horizontal position so as to catch the ore between the furrows made in the previous trip.

The ore is fed from a hopper on to the top hearth, and there dried by the ascending heat. As the ploughs or rakes move to the end of the hearth, they scrape a portion of the ore into an opening, through which it falls on to the second hearth, and so on is transferred to each hearth in succession, meeting in its descent greater heat. The necessary firing is communicated from a small furnace at one end of each roaster. The capacity is stated to be about 50 tons per twenty-four hours, and all work is automatic, the roasted ore being raked by the carriers from the lowest hearths into trucks.

The slag from the smelting furnaces is removed by granulation in a stream of water, which transports it to the slag dumps. When required, the slag is moulded for building purposes; all the walls, floors, stalls, &c., being constructed of this material.

The ore is smelted without flux, being silicious in some parts of the mine, it is mixed so that a slag with about 40 per cent. of silica is obtained. The matte is converted into blister copper (99 per cent.) by Bessemer converters.

The converters—three in number—when first charged, hold perhaps about 1 ton of the molten matte from the cupola furnace; but as the lining is eaten away the charge increases to about 4 tons. Each charge requires about one and a half hours to reduce to metallic copper. After the flame from the converter becomes clear, the slag—iron oxide—is poured off, and the remaining copper subsulphide is further blown upon until the required purity is reached by elimination of the remaining sulphur.

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The copper is further treated at Great Falls—electrolytically—for separation of the contained silver (which in the ore averages about 6 oz. per ton).

The converter lining lasts about twelve hours, and consists of a mixture of silica and plastic clay, ground up and mixed together in proportions suited to the different portions of the converters.

All the flue-dust and slimes are smelted in reverberatory furnaces.

Anaconda Copper Mining and Smelting Company's Reducing Works at Anaconda.

The Company possess two large reducing plants of a total capacity of 14,000 tons of copper per month. The Anaconda plant is most advantageously situated to allow of transfer by gravity from the different treating floors. The ore brought by rail from the company's mine at Butte is first crushed by steam stamps of a capacity of 300 tons each per twenty-four hours. The crushed material then passes through a series of Harz and Cullen jigs, of succeeding fineness of gratings or screens. The slimes pass on to circular tables—buddles—about three sets, one below the other, the last stage being to allow the slime water to pass into settling vats, from which the finest and lightest particles are carried over into large settling tanks. When these have settled, the water is drawn off, and the surface of the muddy slimes is covered with about 6 inches of lime, which absorbs sufficient of the moisture to convert the whole into the consistency of mortar, in which state it can be handled readily.

The concentrates are conveyed wet to the roasting house, in which ninety-six Brückner cylindrical revolving furnaces of a capacity of about 16 tons each are in operation. Each charge requires about twenty-four hours to roast, this being done with wood. The calcined ore is then charged into reverberatory furnaces—no blast furnaces being used—the resulting matte is converted into blister copper in Bessemer converters, and about 10 per cent. of the product passed to the electrolytic department, which was not open to inspection.

Copper Mines of Japan.

From "Copper Mines of the World," by Walter Harvey Weed.

The country contains thirty-eight out of the two hundred and fifty greatest copper mines of the world, besides having as many more mines of small production, but considerable extent and value. Three great mines furnish one half of the annual production of 31,000 metric tons, and there are fourteen mines, each producing 1,000,000 lb. or more yearly. As the production of the country is gradually increasing, and two-thirds of the output is exported, Japan is an important factor in the world's copper market. The production comes partly from silver mines, of which the copper is an important by-product, and from copper ores which contain gold and silver values.

The Japanese deposits are of three main types—(1) veins; (2) impregnations or stockworks, in acid volcanic rocks; (3) lenses of cupriferous pyrite in crystalline schists. The three greatest mines of the country represent these three types, to which most, if not all, the lesser producers may be referred. These three, Ashio, Kosaka, and Besshi, will therefore be briefly described.

Ashio.—The Ashio mines are the largest in Japan. They are located 101 miles north-west of Tokio, and 18 miles from Nikko, in middle Japan. The region is one of Palæozoic clay slates and hornstones cut by the intrusive masses of dacite (and rhyolite) in which the veins occur. There are literally hundreds of veins, some thirty of them being worked. These veins form a

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co-ordinated system of conjugate fractures, with two main directions, viz., north-east to south-west, and north-west to south-east. Each system consists of veins, in pairs, with opposed dips of 60 to 70 degrees. The veins are not wide, averaging 5 to 6 feet thick, and so far have been worked but 400 feet below the lowest adit. The ore consists of pyrite, chalcopyrite, and quartz, and is relatively high-grade, the smelting ore averaging 15 per cent., though lower-grade ore is also mined and milled. The ore shoots are long, averaging 1,000 feet, and are 6 feet thick. The production was 14,622,500 lb. in 1904.

The veins of other localities, as, for example, those of Ani, belong to the class of quartz veins with predominant carbonates, together with barite and fluorite. The Ozarugawa, Kusakura, and Arakawa deposits are of this class, the veins occurring in tuffs and intrusive bodies of rhyolite and propylitic augite andesites that cut Tertiary beds. The ores consist of pyrite and chalcopyrite with hematite, and lead, zinc, and silver sulphides, besides quartz, calcite, rhodochrosite, and barite. In the Kusakura mine, the proportion of specular hematite increases downward. Similar lodes in Palæozoic strata occur at Yoshioka, Sassagatani, and Dogamaru, being dependent on granite and diorite intrusions near by.

Kosaka.—The Kosaka mine, representing the second type, is situated in a hilly region in the extreme northern end of Japan. It is an old silver mine, formerly supposed to be worked out, but now likely to prove the largest copper deposit in all Japan. The region consists of andesitic rocks, mostly tuffs, cut by intrusive masses of rhyolite. The ore deposit is an impregnation of porous volcanic tuff beds alongside of a rhyolite (or dacite) contact. There is a sharply defined hanging wall, but the ore fades gradually into the foot-wall country. The deposit is of enormous size, being from 100 to 600 feet thick, known for 2,500 feet in extent, and proved by drill-holes to 1,700 feet in depth. In the open cuts the deposit varies from 20 to 140 feet across, the deposit extending with the bedding of the tuffs. The ore consists of chalcopyrite and pyrite, with more or less associated sphalerite, cementing and impregnating a volcanic tuff of varying character, being partly a conglomerate and partly a fine grit or arkose. Three grades are mined:—(a) "black ore," a zinciferous sulphide ore with 2·2 per cent. Cu, 2 oz. per ton of silver, and 65c. gold per ton. This ore carries 12 to 18 per cent. zinc, and from 20 per cent. up to 35 per cent. of barite. (b) The pyritic ore proper; carries but 1·8 per cent. copper, and rarely holds tetrahedrite and galena. (c) Silicious ore, low-grade, but necessary in smelting. The production was 9,500,000 lb. in 1905.

Besshi.—The Besshi mine is located in the great island of Shikoku, near Kyoto, in Southern Japan. The deposit is 3,600 feet above tide, in a mountainous region. The district is one of chloritic and graphitic schists, which near the mines contain bands of piedmontite schist, the whole generally enveloped in quartz-schist.

The deposit—an immense mass 6,000 feet long, 4 to 30 feet thick, and over 1,750 feet deep—is intercalated in crystalline schist, and is often called a bedded deposit. The course of the ore body is north 30 degrees east, and it has been worked for 6,000 feet in length. It is usually 10 to 20 feet thick, and not over 60 feet. The bed dips 45 degrees north-east, and is worked by an inclined shaft.

The ore consists of chalcopyrite streaks in crystalline pyrite, with bands and curved and broken slivers of blackish schist. The ore averages between 3 and 4 per cent. copper. The vein is faulted by east to west step-faults, at 45 degrees to the strike, that dislocates the ore body 10 to 20 feet, and never over 60 feet. The production was 10,425,800 lb. in 1902.

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The Kune mine is of the same type, there being three lens-shaped ore-bodies in Palæozoic schists, resembling those of Besshi. The upper bed is 6 feet thick, and the middle one 12 feet thick. The largest ore body is the lowest, and is 80 feet thick, 1,000 feet long, and opened to a depth of 400 feet. The production in 1904 was 30,000 tons of 6 per cent. ore. The ore-bodies are 60 feet apart, lying one over the other. The dip is 50 degrees north-north-west. The Hibira, Hyuga, and Itsuki pyrite ore bodies are of similar type, but occur in Carboniferous slates, near intrusive bodies of quartz porphyry.

Among the lesser but important copper mines of the country, those of Ani, Ozarugawa, Kusakura, and Ogoya are of interest, as being of the spathic copper type. In the Kusakura mine, the largest of those named, the specular iron increases with depth.

Similar veins, cutting the Palæozoic rocks near plutonic intrusives (granites and diorite), occur at Yoshioka, Sassagatani, and Dogamaru.

The Ozarugawa deposit consists of a breccia of propylitic andesite, a greenstone probably in part, at least, an andesite tuff, with a cement of pyrite, bornite, chalcopyrite, and green quartz. The ore is vuggy, and the quartz in place shows curly structure. In part the ore consists of coarsely massive chalcopyrite, showing cavities left by removal of pyrite, or of finely granular pyrite, with quartz vugs and secondary veinlets. It suggests the Kosaka and Boundary Creek type. The mine belongs to the Mitsu Bishi Company.

The Arakawa ore varies from a mixture of chalcopyrite and bornite, showing post-mineral fractures filled by white quartz veinlets and vugs, to a compact mixture of chalcopyrite and quartz. The country rock is a mottled-green brecciated rhyolite and a dense propylitic andesite.

The Makimini deposit consists of finely granular chalcopyrite in lenses in a slaty greenstone and lustrous clay slate, the latter showing interbanded chalcopyrite.

P.S.—Japan produced 42,740 tons of copper in 1906.

AUSTRALIAN Copper Production, 1842 to 1906. Prepared by G. H. Knibbs, Commonwealth Statistician.

Year.	New South Wales.	Victoria.	Queensland.	South Australia.	Western Australia.	Tasmania.	Total Commonwealth.
	£	£	£	£	£	£	£
1842 ...	.....	.....	.....	103	.....	.....	103
1843 ...	.....	.....	.....	127	.....	.....	127
1844 ...	.....	.....	.....	4,000	.....	.....	4,000
1845 ...	.....	.....	.....	17,179	.....	.....	17,179
1846 ...	.....	.....	.....	140,794	.....	.....	140,794
1847 ...	.....	.....	.....	171,883	.....	.....	171,883
1848 ...	.....	.....	.....	310,387	.....	.....	310,387
1849 ...	.....	.....	.....	216,819	.....	.....	216,819
1850 ...	.....	.....	.....	353,890	.....	.....	353,890
1851 ...	.....	.....	.....	309,324	.....	.....	309,324
1852 ...	.....	.....	.....	374,778	.....	.....	374,778
1853 ...	.....	.....	.....	176,347	8	.....	176,355
1854 ...	.....	.....	.....	94,706	.....	.....	94,706
1855 ...	.....	.....	.....	151,827	26	.....	151,853
1856 ...	.....	.....	.....	407,665	1,018	.....	408,683

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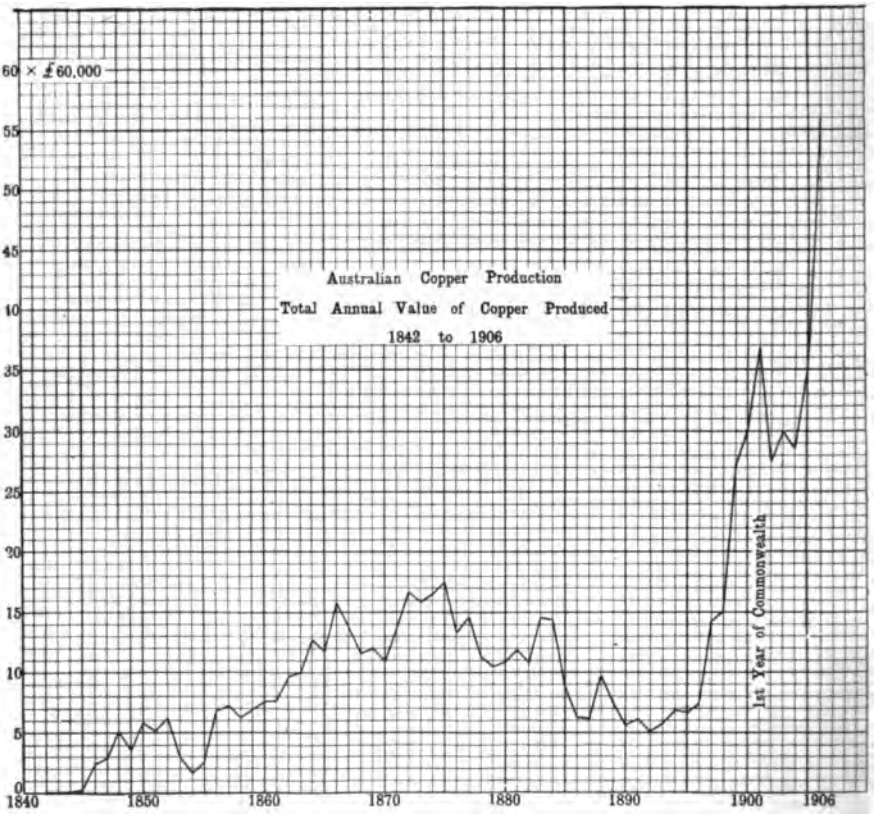

Prepared by G. H. Knibbs, Commonwealth Statistician.

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Australian Copper Production—*continued.*

Year.	New South Wales.	Victoria.	Queensland.	South Australia.	Western Australia.	Tasmania.	Total Commonwealth.
	£	£	£	£	£	£	£
1857	.....	.....	.....	435,174	1,920	.....	437,094
1858	1,400	.....	.....	359,082	9,531	.....	370,013
1859	6,441	.....	.....	397,240	14,123	.....	417,804
1860	9,861	.....	50	435,782	8,021	.....	453,714
1861	3,532	.....	1,450	447,446	6,340	.....	458,788
1862	10,135	.....	10,332	544,372	12,536	.....	577,375
1863	24,399	.....	30,000	532,861	12,208	.....	599,468
1864	6,840	.....	69,000	677,096	17,216	.....	761,152
1865	15,377	.....	58,440	618,472	13,290	.....	705,579
1866	32,290	3,494	91,872	810,192	8,362	.....	947,210
1867	599	1,179	84,200	741,353	5,055	.....	832,377
1868	1,925	1,127	73,020	608,423	1,245	.....	685,740
1869	16,035	.....	76,230	621,825	2,325	.....	716,415
					90	.....	659,457
1893	73,287	.....	3,822	215,260	000	50,000	...
1894	63,617	14,762	9,582	214,727	.....	110,613	413,301
1895	136,989	210	13,097	228,511	12,952	9,677	401,416
1896	197,814	.....	21,042	222,202	100	1,659	442,817
1897	283,174	.....	12,645	242,917	1,033	317,437	857,206
1898	272,686	.....	2,166	249,312	4,286	378,565	906,995
1899	395,451	.....	9,499	420,899	35,928	761,880	1,633,657
1900	425,301	.....	23,040	466,541	42,673	991,660	1,862,215
1901	412,282	.....	194,227	500,077	75,246	1,026,748	2,206,590
1902	307,806	.....	189,200	422,525	8,090	719,146	1,647,767
1903	462,640	500	285,122	472,093	56,541	511,801	1,788,697
1904	406,091	.....	257,899	495,980	26,180	569,053	1,697,099
1905	527,463	.....	503,547	483,431	16,266	563,275	2,093,922
1906	789,527	.....	916,546	743,671	50,237	844,663	3,344,744
Total	8,472,629	123,454	4,402,003	25,575,846	478,129	6,753,561	45,805,622
[1]1907	727,774	2,356	1,028,179	714,525	180,397	866,666	3,319,863
Total	9,200,403	125,810	5,430,182	26,267,734	658,516	7,623,227	49,305,872

[1] Additional production from other sources.

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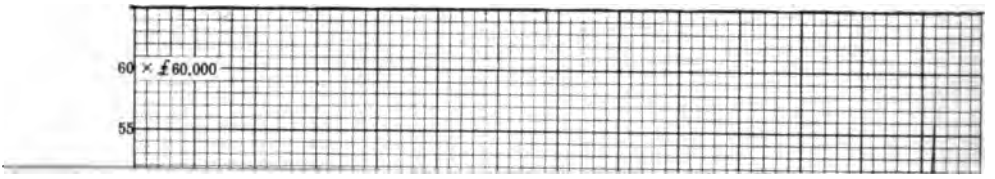


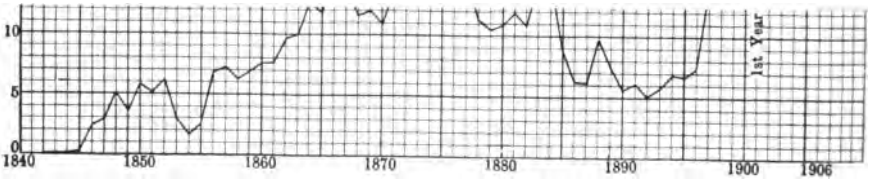
CORRIGENDA.

The Copper Industry of New South Wales.

Page 87, bottom line of table—

5th column—For 26,267,734, *read* **26,290,371.**

8th column—For 3,319,863, *read* **3,322,887**; **and total** should read 49,328,509.



Prepared by G. H. Knibbs, Commonwealth Statistician.

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Australian Copper Production—*continued.*

Year.	New South Wales.	Victoria.	Queensland.	South Australia.	Western Australia.	Tasmania.	Total Commonwealth.
	£	£	£	£	£	£	£
1857	.....	.....	.....	435,174	1,920	.....	437,094
1858	1,400	.....	.....	359,082	9,531	.....	370,013
1859	6,441	.....	.....	397,240	14,123	.....	417,804
1860	9,861	.....	50	435,782	8,021	.....	453,714
1861	3,532	.....	1,450	447,446	6,340	.....	458,788
1862	10,135	.....	10,332	544,372	12,536	.....	577,375
1863	24,399	.....	30,000	532,861	12,208	.....	599,468
1864	6,840	.....	69,000	677,096	17,216	.....	781,152
1865	15,377	.....	58,440	618,472	13,290	.....	705,579
1866	32,290	3,494	91,872	810,192	8,362	.....	947,210
1867	590	1,179	84,200	741,353	5,055	.....	832,377
1868	1,925	1,127	73,020	608,423	1,245	.....	685,740
1869	16,035	.....	76,230	621,825	2,325	.....	716,415
1870	9,772	.....	80,795	568,780	90	.....	659,437
1871	11,828	.....	174,300	637,983	.....	.....	824,111
1872	.....	10	196,000	802,734	.....	.....	998,744
1873	233	30	165,808	768,522	848	.....	955,441
1874	128,980	715	164,040	693,836	998	.....	988,569
1875	175,585	1,776	121,980	753,166	3,071	.....	1,055,578
1876	42,353	.....	147,000	592,000	4,185	.....	790,538
1877	144,441	2,656	167,337	563,010	802	.....	878,246
1878	209,030	33,653	35,126	407,587	135	.....	685,531
1879	210,623	28,324	34,791	351,388	.....	.....	625,126
1880	268,700	17,857	20,137	346,147	120	.....	652,961
1881	267,884	8,166	19,637	418,290	.....	.....	714,003
1882	192,473	1,908	14,982	455,776	23	.....	655,162
1883	472,982	4,644	21,080	375,325	75	.....	874,106
1884	362,287	.....	30,872	469,230	1,770	.....	864,159
1885	170,627	.....	18,920	336,758	1,793	.....	528,098
1886	122,985	1,922	7,000	240,360	3,735	.....	376,002
1887	115,444	.....	7,600	246,235	345	.....	369,624
1888	247,304	10	9,248	327,582	1,488	107	585,739
1889	122,444	175	12,000	308,467	1,904	255	445,245
1890	84,107	100	3,000	252,579	196	56	339,978
1891	119,195	216	865	239,486	4,463	.....	364,175
1892	114,559	.....	2,461	177,680	8,696	.....	303,396
1893	73,287	.....	3,822	215,965	606	45,966	339,646
1894	63,617	14,762	9,582	214,727	.....	110,613	413,301
1895	136,969	210	13,097	228,511	12,932	9,677	401,416
1896	197,814	.....	21,042	222,202	100	1,659	442,817
1897	283,174	.....	12,645	242,917	1,033	317,437	857,206
1898	272,686	.....	2,166	249,312	4,286	378,565	906,985
1899	395,451	.....	9,498	430,899	25,928	761,880	1,633,657
1900	425,301	.....	23,040	466,541	49,673	991,660	1,862,215
1901	412,292	.....	194,227	500,077	75,246	1,026,748	2,208,590
1902	307,806	.....	189,200	432,525	9,090	718,146	1,647,767
1903	462,640	500	285,122	472,093	56,542	511,801	1,788,697
1904	406,091	.....	297,899	436,960	23,180	569,053	1,697,000
1905	527,463	.....	503,547	483,431	16,266	563,275	2,093,922
1906	789,527	.....	916,546	743,671	50,237	844,663	3,344,744
Total	8,472,629	123,454	4,402,003	25,575,846	478,129	6,753,561	45,805,622
[1]1907	727,774	2,356	1,028,179	714,525	180,397	866,366	3,319,863
Total	9,200,403	125,810	5,430,182	26,267,734	658,516	7,623,227	49,305,872

[1] Additional production from other sources.

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Copper Production of the World.

(*The Engineering and Mining Journal*, 30th March, 1907. Quoted from Statistics compiled by Aron Hirsch and Son, Halberstadt, Germany.)

Country.	1904.	1905.	1906.
	Metric Tons.		
United States	366,522	397,545	417,411
Spain and Portugal	50,000	48,000	51,000
Mexico	52,500	60,000	60,000
Chile	33,000	33,000	30,000
Japan	32,700	31,400	37,000
Germany	24,500	25,500	26,200
Canada	21,500	24,000	24,000
Australia	30,000	35,000	43,000
Peru	7,000	8,000	11,500
Russia	10,700	9,000	10,000
Cape Colony	7,250	9,000	8,500
Norway and Sweden	6,000	6,000	6,500
Italy	3,250	3,300	3,100
Newfoundland	2,000	2,200	2,500
Bolivia	2,000	2,000	2,000
Austria-Hungary, including Servia and Bosnia.	1,500	1,500	1,500
Turkey	1,500	1,400	1,000
Other countries	1,300	1,000	1,500
	652,522	697,845	736,711

Of the increase for 1906 over 1905—the United States (19,866 tons), contributed 51·1 per cent. Australia followed with 20·5 per cent., and Japan third with 14·4 per cent. increase.

Of the total estimated world's production of copper between 1901 and 1906, the Commonwealth Statistician places the Commonwealth's contribution at about 5 per cent.

Copper Production of the World, collected and estimated by Henry R. Merton & Co., London.

(*The Engineering and Mining Journal*, 2nd May, 1908.)

Country.	1906.	1907.	Country.	1906.	1907.
United States	409,650	395,090	Sweden	1,500	2,000
Canada	25,460	25,615	Norway	6,120	7,010
Mexico	60,625	56,565	Italy	2,865	3,300
Newfoundland	2,295	1,730	England	750	700
Chile	25,745	26,685	Austria	1,225	920
Peru	8,505	10,575	Hungary	210	125
Bolivia	2,500	2,500	Turkey	425	1,250
Argentina	105	220	Algeria	440	70
Spain and Portugal	49,320	49,675	Cape of Good Hope	6,540	6,730
Germany	20,340	20,490	Japan	42,740	48,935
Russia	10,490	15,000	Australasia	36,250	41,250
			Total	714,100	716,435

Aron Hirsch and Sohn's estimates of production for the same periods :—1906, 752,900; 1907, 706,460. Their estimates of consumption being :—1906, 787,564; 1907, 689,090.

Estimates compiled by the Metallgesellschaft and the Metallurgische A-G. (14th Annual Issue, 1898-1907—March, 1908, p. 5) :—World's production, 1906=717,800 tons; 1907=712,800 tons. World's consumption, 1906=722,500 tons; 1907=674,500 tons.

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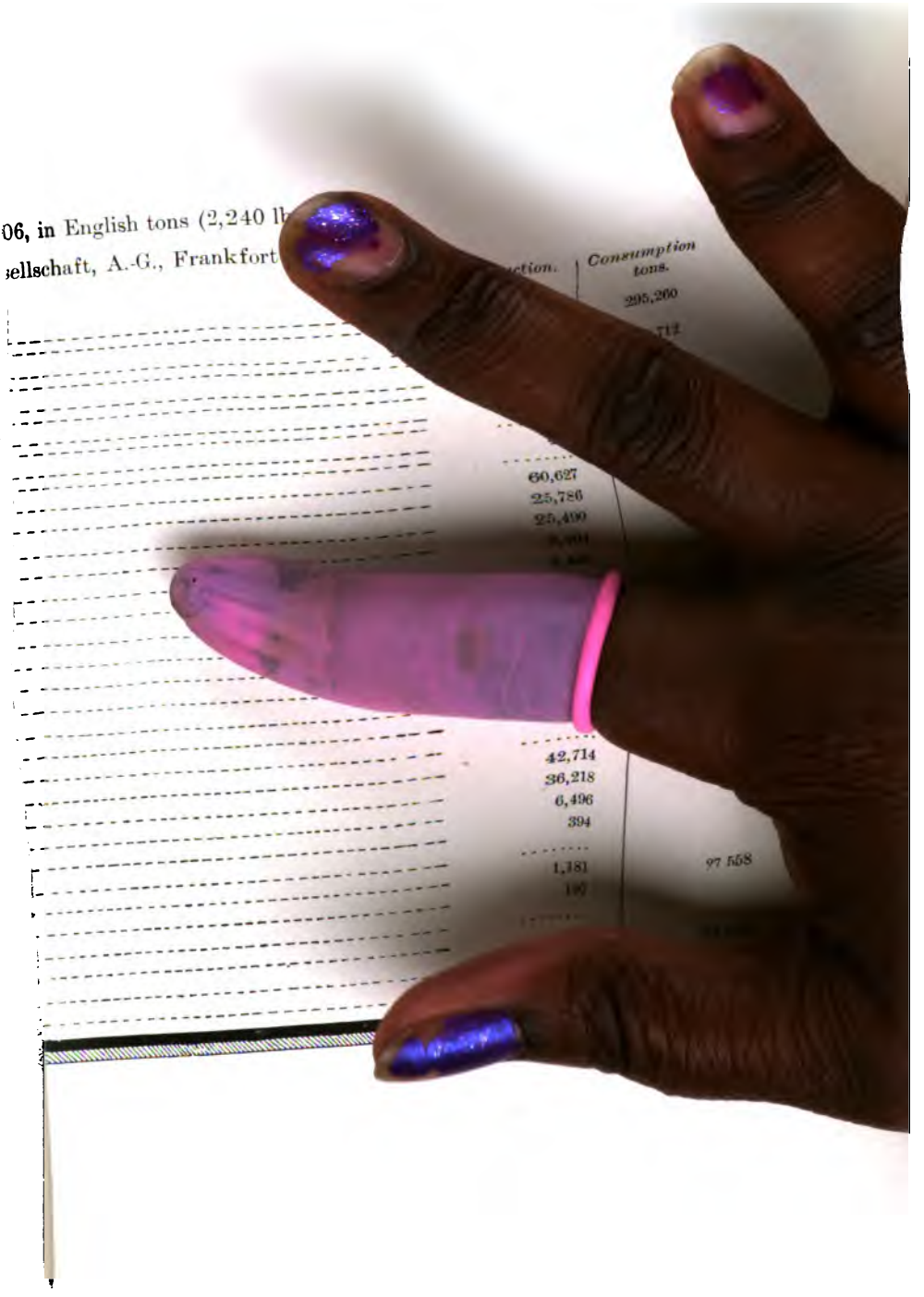

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PERSONS engaged in connection with production of copper in New South Wales and Commonwealth.

(*Commonwealth Year Book, No.* 1, 1908.)

Year.	New South Wales.	Commonwealth of Australia.
1901	2,964	8,103
1902	1,699	6,478
1903	1,816	7,427
1904	1,850	8,038
1905	2,171	10,500
1906	3,047	13,335
1907	3,764	.....

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Descriptive Register of New South Wales Copper Mines and Occurrences arranged in Mining Districts.

ALBERT MINING DISTRICT.

Broken Hill Division.

Alexandra Mine, 1 mile S.E. of Silverton Railway Station, parish Bray, county Yancowinna.

Inspector Carthew reports copper veins in quartz traversing schist, striking N.E. Prospects being encouraging, aid granted to sink 20 feet shaft, a further depth of 60 feet.

Alpine Copper Mine, about 11 miles westerly from Broken Hill, and ½ mile from Red Flag Mine, on parallel vein.

Inspector Milne reported (P.B. $\frac{2}{0}\frac{0}{2}\frac{2}{7}$) veins of copper iron ore in schist, strike N.E.; dip, south-east; channel, about 2 feet wide, containing about 6 inches of ore on footwall.

Aided to continue 43 feet shaft to 93 feet, and to drive 50 feet at bottom. At 93 feet, prospects not as encouraging as at 43 feet. Aided to cross-cut 50 feet; country hard. (No further report.)

Balaclava Iron and Copper Mine, south of Rockwall Paddock, about 10 miles S.S.W. from Broken Hill.—Copper ore was first worked here in 1887 by a company bearing the title of the Balaclava Iron and Copper Company, but operations were not extensive. In 1894, Mr. J. B. Jaquet, Geological Surveyor, reported on the ironstone and copper deposits in the following terms:—"They consist of a series of well-defined parallel lodes, occurring in gneiss and schist. All the lodes dip west at a high angle. One of them, which has a width of 12 feet, can be traced nearly a mile, while others can be traced for several hundred yards. The ore consists of massive hematite, which, on account of its freedom from silica and other impurities, forms a valuable flux for silver-smelting, and large quantities have been used in the smelting works of Broken Hill. The hematite is associated with copper carbonate in some places, and it is possible that the points where the carbonates occur represent the outcrops of shoots of copper ore. No attempt has been made to prove these lodes below 50 feet. In view of the fact that so many of the rich copper deposits in the Australian Colonies and elsewhere are capped by masses of hematite, I would recommend these lodes being prospected to a depth of (say) 200 feet."

In 1896 it was reported that the Wallaroo Copper Mining Company of South Australia was reopening this mine, and had applied for several adjoining leases. The trial was, however, soon abandoned.

NOTES.

(*a*) Unless otherwise specified the assays and analyses herein quoted have all been made in the laboratory of the Department of Mines and Agriculture, under the supervision of Mr. J. C. H. Mingaye, F.C.S., Analyst and Assayer.

(*b*) The registered numbers of assays or analyses are given over the year in which they were made, for example, $\frac{240}{98}$.

(*c*) Official reports quoted will be found in the Annual Reports of the Department of Mines on the pages given under the year of issue, viz., $\frac{1896}{p.\ 80}$.

(*d*) The principal copper occurrences can be located in a comparatively small area by reference to the Mining Divisions on the accompanying map. Some discrepancies may, however, occur, owing to difficulty in ascertaining exact location of some minor occurrences.

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In 1901, Mr. Jaquet further alluded to this mine as one of the most important copper mines in the district, and described the locality as "a belt of country about 2 miles long, and perhaps 300 feet wide, which includes more or less disconnected masses of ironstone. Beneath the ironstone excellent copper ore has been discovered in places.[1] Tributers are reported to have done well in this mine during the same year.[2]

Barrier Range.—In addition to the Broken Hill line of lode, copper ores occur with silver and silver-lead ores in the following mines in the Barrier Range Silverfield, viz.:—War Dance, Red Flag, Copper Blow, Balaclava, Diamond Jubilee.

Twelve miles N.E. of Mt. Gipps copper ores assayed in 1885 from 25 to 43 per cent. of copper.

From the Princess Midas Mine, Purnamoota, auriferous quartz and copper ores were exhibited at the Melbourne Centennial Exhibition, 1888, and similar lodestuff from the Red Jacket Mine.

Inspector J. Hebbard reported (P.B. $\frac{2\,2\,0\,2}{5\,0}$) on the Barrier Queen Copper Mine, which contains lead and silver in addition. Situated about 12 miles from Broken Hill, on the road to Thackaranga, in an easterly direction from the Pinnacle line. Lode 2 feet thick. Formation patchy. Aid granted for proving.

Mr. Hebbard reported (P.B. $\frac{1\,3\,1\,2}{2\,7}$) on the Augusta Mine—M.L. 101, parish Sentinel, county Yancowinna, 23 miles S.E. of Broken Hill. The following extract has been taken from the report:—"Lode traceable by its outcrop for 1½ miles. Lode material consists of heavily iron-stained quartzite, carrying copper and lead in discernible quantities, and well worthy prospecting. Previous efforts in early days of the field confined to deep vertical shafts without touching the lode."

Aid granted to sink from the bottom of an open quarry following the underlay. The lode hereabouts is 4 feet thick.

Aid was also granted for driving at the 200-foot level in the Nine-mile Claim, 6 miles N.W. of Broken Hill, where a strong lode carrying zinc, lead, and copper ore occurs. The copper ore occurring on the west wall of the lode.

Lady Dorothy (formerly Euro) Mine, 9 miles west of Broken Hill, in schist country. Two thin interbedded veins of copper were tested under aid from the prospecting vote (P.B. $\frac{2\,1\,1\,0}{5\,0}$).

Barrier Silver and Copper Syndicate's Mine, M.Ls. 140, 141, and 146, parish Bray, county Yancowinna, about 3 miles N.E. of Silverton. The following particulars of this property were extracted from a report in 1896 by Mr. Joel Phillips, Manager of Broken Hill Junction and Junction North Silver Mines:—"You have on your claims what appears to be a well-defined copper lode, that has been traced and worked upon in places for the full length of your property. On section 140 a shaft has been put down to a depth of 120 feet following the underlie of the lode from the surface. The bearing of the lode is north 11° 30′ west, with a slight dip to the east. By sinking a few feet below the surface, large boulders of green carbonate of copper were met with, and a quantity of ore was broken and sold to the

[1] Ann. Rept. Dept. Mines for 1901, p. 197. [2] *Ibid.*, p. 99.

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English and Australian Copper Company, Port Adelaide. At a depth of about 30 feet the green ore gave place to black and grey ores, intermixed with chalcopyrite and quartz. This class of ore was followed down to the present bottom of the shaft. A little stoping has been done near the bottom, some good parcels of ore having been raised. The lode now standing near the bottom of the shaft I am informed, varies from 2 to 6 feet in thickness of a similar class to the abovementioned. The ore when dressed averages about 30 per cent. of copper. The country rock is decomposed schist."

White Cliffs Division.

Big Wertago Mine, portions 41, 42, parish Wertago, county Yungnulgra.—In 1900 aid granted to sink 100 feet. At 55½ feet Mr. Warden Fletcher reported a fair percentage of copper in lode matter. No walls visible. Ironstone at 60 feet, followed by ore, then ironstone (gossan) to 80 feet. Good ore at 85 feet, then gossan. At 100 feet ore chiefly carbonate and oxide. Driven 10 feet west to foot-wall, and 25 easterly without wall.

Aided to continue shaft to 150 feet. Ore showing at 146 feet. Water coming in. Work suspended.

In 1901 Chief Inspector J. B. Jaquet, reporting on the Big Wertago and adjoining blocks upon the western slopes of the Cootawundy Range,[1] stated:—"We find here a belt of country—conglomerates, sandstones, and quartzites—more or less impregnated with copper carbonates, and including bunches of rich ore. The belt can be traced for at least 5 miles, and copper ore, or country stained with copper carbonates, can be seen outcropping at intervals along its course."

Upon Block 41, one of the blocks owned by the Big Wertago Company, an open cut has been carried for a distance of 50 feet upon an ore body, which has an average width of about 4 feet, and several tons of excellent carbonate ore have been raised. Two shafts have been sunk upon this block to depths of 60 and 154 feet respectively. These shafts encounter bunches or pockets of carbonate ore. Small quarries have been opened upon ore-bodies at many other places along the belt.

In September, 1907, Inspector Sawyer reported that the Main South Shaft had been carried down to 177 feet, and cross-cuts put in east and west. An option over the mine by Messrs. Riechers provides for erection of a small concentrating plant to deal with ore at grass and in sight. The plant to embrace engine, jaw-crusher, roller, shaking screen, May Bros. jigs, and, if necessary, Wilfley tables. Water for mill to be obtained from shaft, estimated as equal to 3,000 gallons inflow daily. A concrete storage reservoir of 10,000 gallons capacity to be built on an elevation overlooking the mill. A large earthen dam has been erected across an adjacent gully.

Broken Hill Division.

Black Lead, about ¾ mile east of White Lead Tank.—Inspector Milne reported (P.B. $\frac{4}{1}\frac{8}{2}$) a quartz vein impregnated with grains of bornite and chalcopyrite in schist. Formation about 15 feet wide. Copper-bearing vein on hanging wall.

Aided to continue 94 feet shaft, other 175 feet. Prospects reported more promising at 144 feet. At 191 feet 6 inches occasional small rich bunches of ore met during sinking. (No further work).

[1] Ann. Rept. Dept. Mines for 1901, p. 168.

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ALBERT MINING DISTRICT—*continued.*

Birdite Mine.—Portion 10, parish Ophara, county Yancowinna, about 14 miles north-westerly from Cockburn Railway Station. Reported to have been discovered by Thomas Calderwood in 1883.

Inspector Carthew reported quartz with copper veins, thickness 15 feet, strike N. 30° W., dip S. 60° W.; schist country; ores, carbonate and oxide of copper carrying silver.

Maximum length of proving, 40 feet; depth, 80 feet; gross output, about 20 tons, averaging 16 per cent. of copper and 8 oz. of silver per ton.

Aided (P.B. $\frac{2}{0}\frac{6}{7}\frac{0}{0}$) to sink 100 feet following underlay; also to crosscut 100 feet.

White Cliffs Division.

Brady's Proprietary Mine, Wertago.—M.L. 117, parish Wertago, county Yungnulgra.

Chief Inspector Jaquet reported[1] two important lodes in this mine, trending N.E. and S.W. Upon the outcrop of ore an open cut has been carried for a distance of 100 feet, and ore quarried for a width of from 3 to 10 feet.

Rich ore raised from this quarry, and smelted at Wallaroo, yielded:—

4½ tons = 29·5 per cent. copper.
4 tons 18 cwt. = 20·5 per cent. copper.

The parallel lode is well defined, and from 1 to 2 feet wide, and has been traced in trenches for many chains. The outcrop is stained with copper carbonate in places, and from some of the trenches a few tons of excellent ore have been raised. An underlay shaft has been sunk to a depth of 40 feet on the lode, and ore was met with all the way down.

Inspector Godfrey reported (P.B. $\frac{4}{0}\frac{1}{1}\frac{1}{4}$) a well-defined lode, dipping at about 70°, and about 4 feet wide; hanging wall defined, but impregnated with copper ore; no defined foot-wall. Ores consisted of erubescite and carbonates with gypsum.

Aid granted to continue 38 feet shaft other 50 feet, but does not appear to have been availed of.

Broken Hill Division.

Broken Hill Proprietary Silver Mine.—In the famous Broken Hill lode copper ores are disseminated in the form of carbonates, red oxide, and native copper, with other rarer varieties, including a new mineral—Marshite—(iodide of copper).

Copper (in matte) produced since inception of company to 30th November, 1906, amounted to 4,576 tons. None produced in 1907.

Broken Hill District, about 6 miles N. of Purnamoota, and 25 miles N.W. of Broken Hill.—Inspector Milne reported (P.B. $\frac{2}{0}\frac{0}{2}\frac{0}{0}$) schist rock with veins of copper carbonate, fairly well defined, and about 9 feet thick.

Aided to sink from 75 feet to 105 feet and to drive 50 feet at bottom.

At 97 feet copper vein continuing, but no improvement visible.

At 101 feet 6 inches prospects only moderate, veins much pinched.

Aided to sink a further 50 feet; at 114 feet nothing payable disclosed. At 120 feet veins of copper ore in quartz in schistose rock.

Abandoned at 127 feet, small veins in bottom.

Broken Hill District.—M.L. 36, parish of Tara, county Yancowinna, Mt. Darling Creek, about 10 miles easterly from Broken Hill.—Chief Inspector J. B. Jaquet reported (P.B. $\frac{2}{0}\frac{0}{0}\frac{0}{0}$) an outcrop well defined cutting across the

[1] Ann. Rept. Dept. Mines for 1901, p. 168.

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bedding planes of the schists. Traceable for several chains. Lode consists of gossany ironstone impregnated in places with copper carbonates. No payable ore to 30 feet.

Aided to continue underlay shaft from 30 feet to 80 feet, and to drive 50 feet at bottom.

Inspector Godfrey reported (P.B. $\frac{4}{6}\frac{1}{0}\frac{0}{0}\frac{1}{1}$) that at 67 feet ore consisted chiefly of porous ironstone without copper from 30 to 63 feet in shaft, when stains of green carbonate appeared.

Aided to sink an additional 50 feet instead of driving. At 91 feet prospects about the same as at 63 feet. At 115 feet passed into barren country.

Broken Hill District, about 4 miles N.E. of Acacia Dam, and 12 miles S.W. of Broken Hill.—Inspector Milne reported (P.B. $\frac{4}{0}\frac{2}{1}\frac{7}{1}\frac{1}{1}$) vein of copper ore in schist, consisting of cuprite, black ore, and carbonates. Vein well defined and carrying pockets of rich ore.

Aided to continue 55-foot shaft to 105 feet, and to drive 50 feet at that level.

At 86 feet, a small quartz and ironstone vein which at 103 feet varied from 3 inches to 8 inches in thickness, and carried rich bunches of red oxide.

At 29 feet in drive from 100-foot level, prospects not good. Nothing payable disclosed.

Broken Hill District, about 8 miles southerly from Broken Hill, near the North Pinnacle, parish Alma, county Yancowinna.

Inspector Carthew reported (P.B. $\frac{1}{0}\frac{6}{5}\frac{8}{8}$) a copper lode striking N. 30° W., width 20 feet.

Aid granted to sink from 15 to 65 feet. At 25 feet, lode reported as improving. At 41 feet, lode reported encouraging. At 49 feet, country very hard; more ore than formerly. No further record.

Broken Hill District, 20 miles northerly from Broken Hill, about half a mile west of Yanco Glen Hotel, parish Waukeroo, county Yancowinna, about 2 miles from Tarrawingee tram-line.

Inspector Carthew reported (P.B. $\frac{1}{0}\frac{1}{5}\frac{0}{8}\frac{1}{1}$) a quartz reef carrying copper ore; strike, N. 30° W.

Aid granted to continue centre shaft from 9 feet to 59 feet. At 36 feet two small veins of copper ore showing, not encouraging in appearance. At 50 feet prospects improved; copper vein opened out.

Additional 50 feet of sinking allowed. At 64 feet water struck; lode 3 to 9 inches thick of copper pyrites. Abandoned; water too heavy; capital insufficient.

Broken Hill District, 15 miles due N.E. of Broken Hill, on north side of Mulga Springs Creek, and about three-quarters of a mile N.N.W. of platinum deposit, parish Moorkaie, county Yancowinna.—Inspector Sawyer reported this occurrence, 18/2/07.

Mr. G. W. Card epitomised results of elaborate testing of this ore by Mr. J. C. H. Mingaye, as follows ($\frac{1}{0}\frac{1}{7}\frac{7}{1}\frac{2}{1}$):—

Nickel present	0·3 to 4·3	per cent.
Copper ,,	0·7 to 10·8	,,
Cobalt, up to	0·2	,,
Platinum, up to	9½	dwts. per ton.
Palladium, up to	16	,,

Iridium in excess of platinum and palladium.

(Ore from the above locality forwarded by A. Figgins, prospector, Broken Hill.)

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ALBERT MINING DISTRICT—*continued.*

Resemblance to famous Sudbury nickeliferous pyrrhotite of Canada, pointed out by Mr. Mingaye.

Very similar metallic association has been determined in ore from the Walhalla or Thompson's River Copper Mine in Victoria. The following analysis of concentrates from a sample of this ore is by Mr. P. G. W. Baly, A.R.S.M.[1]

Analysis of Concentrates.

Insoluble matter	19·0 per cent.	Impossible to isolate indications of gold and platinum.
Iron	30·0 ,,	
Copper	8·1 ,,	
Nickel	0·7 ,,	
Sulphur	30·4 ,,	
Magnesium carbonate	7·0 ,,	
Calcium carbonate	3·7 ,,	
Cobalt	trace.	
	98·9	

Other assays, by A. E. Glover and C. M. Lyons, yielded the following results from hornblendic rock with chalcopyrite from the above mine :—

	A	B	C		
Gold	2 dwt.	12 grs.	12 grs.	1 dwt.	2 dwt. per ton.
Silver	18 grs.	8 dwt. 11 grs.	5 dwt. 21 grs.	13 dwt. 7 grs.	1 oz. 2 dwt. per ton.
Platinum	7 dwt. 20 grs.	5 dwt. 18 grs.	2 dwt. 18 grs.	5 dwt.	2 dwt. 14 grs. per ton.
Copper	6·93%	3·47 %	1·70 %	3·25 %	5·027 %

25 tons of this ore yielded at Cockle Creek,—copper, 6·5 per cent. ; silver, 2 oz. ; and platinum, 2 dwt. per ton.

Broken Hill District, Boomerang Hill, 3 miles S.E. of Mount Hornsby and 30 miles N.E. of Broken Hill, about half a mile north of Broken Dam.—Inspector Sawyer reported (P.B. $\frac{10}{08}$) a quartz reef in this locality carrying copper carbonates and pyrites in schist country. Strike E. and W. Small rich vein of copper ore showing in shaft. Aid granted to sink from 26 to 76 feet. At this level small vein of copper ore showing. No further report.

Broken Hill District, M.L. 119, parish Sebastopol, county Yancowinna, 10 miles west of Broken Hill.—Inspector J. R. Godfrey reported in connection with application for prospecting aid, that a copper lode occurs in this lease in talc schist. At 33 feet a good ironstone vein was going down strongly.

Aided to continue shaft to 100 feet. Progress of developments recorded (P.B. $\frac{12}{05}$) are as follow :—At 56½ feet, prospects improving ; at 79 feet, lode widening ; small patch of malachite near that level ; cut off north-east by cross-course ; at 88 feet, large soft formation encountered on hanging wall, with traces of copper.

Fifty feet of cross-cutting granted ; splashes of copper ore in soft schist and slate met in cross-cut ; no further test ; abandoned.

[1] Bull. Geol. Survey Victoria, 1906, No. 20, pp. 8-10.

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ALBERT MINING DISTRICT—*continued.*

McGrath's Copper Lode.—Chief Inspector W. H. J. Slee reported[1] that the ore was visible on the surface in a bunch, 20 feet in length. Five tons sent to Adelaide are reported to have yielded 12 per cent. of copper.

Two miles north of May Bell Mine, Inspector J. R. Godfrey (P.B. $\frac{2}{0}\frac{2}{2}\frac{2}{2}$) described a well-defined copper lode, striking north-east, in schist; about 4 feet wide.

Aided to 58 feet; no record.

Broken Hill District, 1 mile from Fairy Hill, 30 miles north-east of Broken Hill.—Inspector Godfrey reported (P.B. $\frac{1}{0}\frac{6}{4}\frac{2}{}$) copper lode in schist; strike, E.N.E.; dip, E.S.E.; nearly vertical. Ores consisted of quartz with grey ore and carbonates, about 2 feet wide. (1 ton of picked ore yielded 35 per cent. of copper.) Lode described as well-defined between good walls. Aided to sink 80-foot shaft to 130 feet. At 80½ feet, small but rich vein of copper ore, consisting of native copper, cuprite, and grey ore.

At 99½ feet, a bunch of cuprite, copper glance, and pyrites cut.

Fifty feet of driving along lode allowed, a small vein in face of E.N.E. drive. In face of W.S.W. drive 12 inches of quartz; prospects poor.

Fifty feet additional sinking granted, but not availed of.

Broken Hill District, about 2 miles south of Purnamoota-road, in parish Stephen, county Yancowinna.—Inspector Carthew reported (P.B. $\frac{1}{0}\frac{3}{6}\frac{1}{2}$) quartz containing copper; strike, E.N.E.; dip, nearly vertical.

Small vein of copper ore carried down 27 feet in shaft. Though aid was granted to continue to 100 feet, it was not availed of.

Broken Hill District, portion 16, parish Narradin, county Yancowinna.—Inspector Hebbard reported (P.B. $\frac{2}{0}\frac{8}{9}\frac{1}{}\frac{2}{}$) quartzite with zinc-blende in schist country. Proved for 200 feet in depth, and by drives aggregating 150 feet at 60 feet and 100 feet levels. Examination of results disclosed a strong body of zinc-blende and copper ore.

Broken Hill District, 2 miles south of Pinnacles, in parish Alma, county Yancowinna.—Inspector Carthew reported (P.B. $\frac{2}{0}\frac{0}{6}\frac{1}{}\frac{2}{}$) a copper vein in quartz and ironstone in this locality, striking E. and W., and dipping north; promising outcrop traceable for a long distance.

Aid granted to sink 20 feet shaft to 70 feet, but was not used as copper was reported to have cut out at a shallow depth.

White Cliffs Division.

Bunker's Hill Mine, M.Ls. 25 and 26, parish Wertago, county Yungnulgra.—Chief Inspector J. B. Jaquet reported[2] that the outcrop of the lode was traceable for nearly half a mile on a N. 30° E. strike. It consists of quartz stained in places with copper carbonates. An open cut has been made along the lode for 100 feet, to a depth of 16 feet. From this two parcels of ore, despatched to Wallaroo, yielded :—

2 tons 7 cwt. = 29·5 per cent. copper.
2 tons 10 cwt. = 23·8 per cent. copper.

About 40 feet from the open cut a vertical shaft has been sunk 100 feet, the bottom being in quartz, with a little copper. The lode has a slight underlay, and shaft does not appear to have reached the foot-wall.

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[1] Ann. Rept. Dept. Mines for 1883, p. 126. [2] *Ibid.*, 1901, p. 168.

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ALBERT MINING DISTRICT—*continued.*

In Bunker's Hill No. 3 Block the same lode is being worked; a large quarry being opened in the outcrop, and a shaft sunk 100 feet.

Inspector B. Sawyer reported, 10th September, 1907, that the Bunker's Hill claim was worked by Barron and party, and a small output of mixed carbonates obtained from a new underlay shaft a little to the south of the 103 feet vertical shaft. At 40 feet, lode appeared to average 12–18 inches; 30 tons ore raised during past three years.

Broken Hill Division.

Copper Blow Mine, 3 miles N.E. from Thackaringa Hotel, near Silverton Road, parish Albert, county Yancowinna.—Inspector Carthew reported (P.B. $\frac{2}{3}\frac{1}{7}\frac{2}{2}$) a copper vein in schist. Strike, N. 32° E. Dip, N. 58° W.

Aided to continue 29-foot shaft a further depth of 50 feet. Whip erected to cope with water.

Copper King Mine, M.L. 55, parish Tara, county Yancowinna, 10 miles east of Broken Hill.—Mr. E. F. Pittman, Government Geologist, reported (P.B. $\frac{2}{3}\frac{1}{7}\frac{2}{2}$) that country consists of banded quartzites close to mica schist. Quartzite stained with copper carbonates for a considerable width; and what appeared to be a lode of somewhat richer material had been exposed in an open cut dipping westerly towards the shaft. Previous holders had sunk the latter to 60 feet.

Aid granted to continue to 100 feet, and to cross-cut 50 feet at bottom.

Progress: At 91 feet, traces of black ore occasionally, not encouraging. At 38 feet in cross-cut, prospects bad. At 50 feet, only specks of ore. Good surface-show only. Output from shallow openings, about 40 tons of dressed ore, containing 10 per cent. copper.

White Cliffs Division.

Copper Well Mine, Wertago, M.Ls. 113, 114, parish Wertago, county Yungnulgra.—Chief Inspector J. B. Jaquet reported:—"The lode here is well-defined, and, as seen in the workings, has an average width of over 2 feet. A shaft was sunk, thirty years ago, in search of copper ore, and a good flow of water being met with, it was utilised as a well for watering stock Shaft, 150 feet deep; levels driven at 100 feet for 60 feet south-westerly, and 90 feet north-easterly, upon the lode. Excellent carbonate ore can be seen in many places, both in the floors and backs of the levels. The lode is nearly vertical, but passes to west of shaft at 100 feet in depth.

"About 500 yards from the shaft northerly, two veins carrying copper have been discovered. These veins are respectively 1 foot and 8 inches wide, separated by 7 feet of country. Outcrops traceable for several chains.

"Two small parcels of ore have been despatched from the mine:—

1 ton 13 cwt. yielded 30·75 per cent. of copper.
1 ,, 1 ,, 28·75 ,, ,,[1]

"In 1906 the Copper Well Mining Company (Limited) was formed, and entered into possession in September; work being started towards end of year. Four tons of 25 per cent. ore despatched.

"In February, 1907, 10 tons of ore from the 100-foot level, assaying 31·25 to 38·6 per cent., were despatched to Adelaide. In March, 10¼ tons realised £26 per ton net."

[1] Ann. Rept. Dept. Mines for 1901, p. 168.

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ALBERT MINING DISTRICT—*continued.*

Inspector B. Sawyer, in September, 1907, reported:—"These leases were lately exploited by a Cobar syndicate, but after carrying a cross-cut, 60 feet to the lode at the 150-foot level of the shaft, and then driving along the lode 30 feet each way, the mine was let on tribute to Grey and Field, who have raised about 10 tons of grey ore containing about 29¼ per cent. of copper. The lode in the lower levels is said to be about 10 inches wide, and carries gossany veins impregnated with copper."

Broken Hill Division.

Diamond Jubilee Mine, M.L. 150, parish Robe, county Yancowinna, 23 miles northerly of Silverton.—A company was registered in 1897 to work this property. Shaft sunk 67 feet. A 20-ton trial of the ore reported to have yielded 19 per cent. of copper, and 17 dwt. of gold per ton.

Inspector Hebbard, who examined this occurrence in 1898 (P.B. $\frac{1}{8}\frac{5}{8}\frac{2}{8}\frac{2}{8}$), states that it occurs close to Para Creek, about one mile west of Yuba Silver Mine, in parish Robe, county Yancowinna, and described the locality in the following terms:—"There are evidences of abundance of ore all over the property, but so far it does not seem to make down. The ore deposits have been opened in forty or fifty places on the property, and everywhere have proved copper and gold bearing. Parcels of picked ore have yielded up to 2 oz. of gold per ton, and 24 per cent. of copper, and several tons of this class of ore have been disposed of."

Mr. Hebbard was of opinion that there was a great quantity of ore on the surface that would pay to concentrate.

At a later inspection no defined lode had been proved. A shaft had been sunk 60 feet in one deposit—ore was visible at 20 feet, but none at bottom.

The ore consists of copper-stained, gossany quartzite, and invariably contains gold associated with the copper. Aid granted to further prospect.

Inspector Carthew reported in 1904 (P.B. $\frac{2}{0}\frac{7}{4}\frac{2}{4}$) that three or four parallel veins occur.

White Cliffs Division.

Eclipse Copper Mine, M.Ls. 1 and 117, 80 acres, parish Wertago, county Yungnulgra, 60 miles from Wilcannia.—Reported to have been discovered by E. Barron in 1892.

Strike, N. 60° W.; dip, N. 30° E. in micaceous schists and slates. Width about 4 feet.

Inspector J. Carthew stated that the maximum length of proving in 1906 was 200 feet, and the depth 125 feet.

Inspector B. Sawyer reported in September, 1907, that Blocks 1 and 117 were being worked by Barron and party. Shaft, 140 feet; drive, N.E. along lode extended 50 feet to intersect winze from level above.

At 108-foot level the lode carried good grade copper sulphides up to a maximum width of 2½ feet.

Output during past three years (1905 to 1907) amounted to 200 tons, yielding from 25 to 30 per cent. Appears to be so far the only mine at Wertago producing sulphides.

Blocks 125 and 126 held by the same party furnished 7 tons of ore in 1907, realising £104.[1]

[1] Ann. Rept. Dept. Mines for 1907, p. 51.

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Albert Mining District—*continued.*

Broken Hill Division.

Fairy Hill, M.L. 56, parish Gardner's Creek, county Mootwingee, 34 miles N.W. of Broken Hill, and 2 miles from Fairy Hill.—Inspector J. R. Godfrey reported (P.B. $\frac{20}{0}\frac{3}{2}\frac{A}{}$) two copper lodes in schist; strike, N.W., dip, N.E. at 70°; separated by 4 feet of mullock. Followed down to 70 feet between well-defined walls containing seams of copper ore. The lode broke into strings at that level. Shaft continued to 100 feet.

Aid was granted in sinking to 62 feet, and for driving 50 feet at 70-foot level. At 22 feet in drive, lode ran about 3 feet wide, with a little copper ore on hanging wall. At 42 feet lode pinched very small. Apparently not followed further.

Nine tons of ore despatched during operations yielded 8½ per cent. of copper.

Federal Copper Mine, about 7 miles north of Silverton, parish Umberumberka, county Yancowinna.—Inspector Hebbard reported (P.B. $\frac{3}{9}\frac{L}{8}\frac{6}{}$) a quartz lode 2 feet wide containing copper ore, but not in payable proportion. Shaft down 60 feet. Aided to continue to 160 feet.

About 3 tons ore despatched from shaft and drive netted about £9 per ton.

Inspector D. Milne reported (P.B. $\frac{2}{0}\frac{A}{1}\frac{A}{}$) ironstone and quartz, with small bunches of ore at 161 feet. Aided for further 25 feet of sinking.

At 190 feet ore reported as improving. Aided to drive south along it for 50 feet.

At 20 feet in south drive a 6-inch vein of red oxide in schist encounted, worth 20 per cent. copper. Vein continued at an equal thickness.

Aided to sink from 218 feet to 268 feet.

Inspector J. Carthew reported (P.B. $\frac{2}{0}\frac{A}{4}\frac{A}{}$) that shaft had been sunk all the way in a "pinch" or narrow part of the lode.

Aided to drive south at 269-foot level.

In driving 42 feet about 3 tons of ore raised. From 250 feet an ore vein 12 inches wide was stoped upwards. Forty-four and a half tons of ore despatched averaged about 19 per cent. of copper.

Florence Mine, one mile west of Silverton, and about one mile east of the Umberumberka Silver Mine, parish Bray, county Yancowinna.—Inspector Carthew reported (P.B. $\frac{2}{0}\frac{A}{7}\frac{A}{}$) quartz containing copper ore in slate and schist. Strike, N.E.

Aided to sink to 80-foot level, and cross-cut 60 feet from the latter.

At 65 feet a parallel vein was cut through, dipping south. Additional aid for cross-cutting granted. Several small veins of copper met.

Glencoe Mine (also Lady Dorothy), portion 311, parish Stephen, county Yancowinna, about 10 miles north-westerly from Broken Hill.—Inspector D. Milne reported (P.B. $\frac{A}{0}\frac{A}{4}\frac{A}{}$) a vein of green carbonate of copper about 1 foot 6 inches thick in schist.

Aided to sink No. 2 shaft from 75 feet to 105 feet. At 103 feet patches of good ore exposed, but not in payable quantity.

Also examined by Inspector J. Carthew, who described the lode as quartz containing copper and silver, and striking N.W. Further aid granted to drive 50 feet along the lode at the 105-foot level (P.B. $\frac{A}{0}\frac{A}{4}\frac{J}{}$).

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ALBERT MINING DISTRICT—*continued.*

Mr. E. F. Pittman, Government Geologist, describes the country as highly inclined schistose rocks, with a couple of copper veins interbedded with the schists. The veins containing promising ores consisting of carbonate and oxide of copper, only a few inches wide (P.B. $\frac{8}{10}\frac{11}{10}\frac{0}{0}$).

Inspector Carthew again inspected in 1907, and reported the veins of ore as widening with depth. Hard sinking and increase of water caused abandonment.

White Cliffs Division.

Grassmere Mine.—Inspector B. Sawyer reported in September, 1907, that M.Ls. 1 and 2 of 40 acres forming this property, are situated in parish Daubney, county Yungnulgra, 8 miles from Grassmere Station, and 43 miles from White Cliffs, on Euriowie-road. They were then being exploited by Messrs. Francis and Dreher. Old shaft, 40 feet deep; lode extensively opened by surface cuts; strike, E. and W.; lode mostly grey ore; some 200 tons at grass. A trial parcel of 50 tons of about 30 per cent. (according to owners), being ready for despatch.

It was further reported that some 500 tons of ore were raised during 1907, of which 200 tons were disposed of for an average return of 10 per cent. of copper.[1]

Broken Hill Division.

Hampton Copper Mine, about 6 miles easterly from Broken Hill.—Chief Inspector J. B. Jaquet reported[2] that a shoot of rich copper ore, of an average width of 8 inches, and a length of 20 feet, had been followed down 85 feet. About 33 tons of ore, assaying 25 per cent. of copper, being despatched to South Australia.

Hornsby Range, about 22 miles from Broken Hill, and 8 miles from the Tarrawingee tram-line. According to the *Barrier Miner*, of the 13th July, 1898, a number of copper lodes were being opened at the above locality. A first parcel of 10 tons, of about 12 to 15 per cent. ore, had been prepared for shipment.

Invincible Copper Mine, 11 miles S.W. of Broken Hill, and 1½ miles from Acacia Railway Siding.—Inspector J. Hebbard reported (P.B. $\frac{8}{10}\frac{8}{8}\frac{8}{8}$) that three shafts have been sunk on the lode, the course of which is regular and well-defined, and about 4 feet thick. The richest shoot had been worked to a depth of about 60 feet, when the shaft passed through it. A drive to the south proved the continuance of the lode in that direction, though poorer; numerous indications of copper and other ores occur in the vicinity.

Milparinka Division.

Kooningbery Mountains, near Packsaddle and Wonaminta.—The Warden, under date 29th July, 1898, stated that a mineral prospecting protection area was pegged out for copper in this locality. The prospects were fair, but no developmental work had been done on which to base an opinion of the deposit.

Samples, numbered $\frac{3372 \text{ to } 3374}{98}$, yielded 25 to 40·82 per cent. of copper. They consisted of red oxide and green carbonate.

In 1904, 20 tons of copper ore raised from J. Sullivan's mineral lease at Kooningbery Range, sent to Adelaide for treatment, yielded 15 per cent. Shaft down 130 feet in lode; 6 feet wide at bottom.[3]

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[1] Ann. Rept. Dept. Mines for 1907, p. 51. [2] *Ibid.*, 1901, p. 167. [3] *Ibid.*, 1904, p. 46.

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ALBERT MINING DISTRICT—*continued.*

During 1905 little work was done, 16 tons despatched from an open cut yielded 25 per cent.[1]

Broken Hill Division.

Lady Hampton Mine, 6 miles east of Broken Hill, parish Bolairo, county Yancowinna.—Inspector J. R. Godfrey reported (P.B. $\frac{2\,2\,1\,6}{0\,0\,\frac{1}{2}\,0}$) a copper lode in schist; strike N. 10° W.; dip. S. 80 W. at 75°.

Some good ore obtained from a pipe lens down to 100 feet; 49½ tons despatched, of an average grade of 27 per cent. copper.

Aided to continue 113 feet shaft to 163 feet, and to drive from bottom 75 feet on lode.

At 153 feet a well-defined lode formation reported, but little ore (no further record).

Mootwingee Copper Mine (also referred to as Mannerings).—In 1880 the Mining Registrar reported that four men were employed in this mine. Copper carbonates had been struck at 9 feet, assaying 29 per cent. copper. Sample $\frac{2\,6\,2\,2}{9\,0\,\frac{1}{2}\,0}$, from Mootwingee, yielded copper 41·40 per cent., and 20 oz. of silver per ton.

Nadbuck Copper Mine.—Five miles from Broken Hill, parish Nadbuck, county Yancowinna.

Iron-stained quartz and gossan copper-stained. Outcrop strong. Bunch of ore at 10 feet yielded 24 per cent. ore.

Aided to sink to 80 feet. At 60 feet prospects reported very poor.

In 1901, Chief Inspector J. B. Jaquet reported the width to vary from 1 to 3 feet. Proved to 200 feet; yielding a quantity of rich ore. During eight months ending 15 June, 1901, about £900 worth of ore raised.

In 1906 it was reported that 335 tons of ore had realised £2,280 net.

White Cliffs Division.

Nuntherungie Copper Mine.—Embracing the Cootra, Tarella Consols, and the recently named Wertago Mines. Situated about 72 miles from Wilcannia, on the Milparinka-road, and about 15 miles from Nuntherungie home station, parishes Wertago and Woraro, county Yungnulga.

In 1892, J. B. Jaquet reported that more than twenty years prior several tons of copper ore, raised from shafts sunk near the western base of the Cootawundy Range, were sent to South Australia, *vid* Wilcannia, for treatment. Notwithstanding the high price of copper then prevailing, it was found that the lodes could not be worked at a profit in that isolated district.[2]

Mr. Jaquet further states that several lodes, composed of quartz with copper carbonates and decomposing copper pyrites, occur in the sandstones on the eastern side of the field. In some places carbonates, resulting from decomposition of pyrites, have been deposited in the interstices of the sandstone, which, from its copper-stained appearance, has given rise to an erroneous impression of a vast broad outcrop of a copper-bearing lode.

Warden J. W. Fletcher, under date 21st March, 1899, stated that the copper-bearing country lies along the base of the Cootawundy (sometimes

[1] Ann. Rept. Dept. Mines for 1905, p. 44. [2] *Ibid.*, 1892, p. 138.

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ALBERT MINING DISTRICT—*continued.*

called the Copper Mine) Range, the cupriferous belt having a length of about 6 miles, by a width of 4 miles. Sixteen leases were taken up in February, 1889. The following extracts are from the Warden's report:—

"M.Ls. 125 and 126, parish Woraro.—The copper outcrop runs the length of the two blocks, the lode being of good size. An old shaft, 25 feet deep, sunk on the lode in the early workings; 20 to 25 tons of ore at grass. There is also a fair-sized ironstone lode on the ground, carrying silver and copper.

"M.Ls. 113 and 114, parish Wertago, lying south-east of M.Ls. 125 and 126, contain the old copper mine well. These blocks were formerly known as the Tarella Consols. The lode in them is reported to have been sunk on 110 feet. About 6 tons of dressed ore are lying at the mine, and a quantity of unsorted. The lodestuff consists of grey ore and green carbonates, in a gossan formation of good width. The lode is traceable through the length of the blocks, the width varying from 3 to 10 feet. An assay of the sorted ore is reported to equal 39 per cent. of copper, with traces of gold and silver.

"M.Ls. 118 and 119, south of M.Ls. 113 and 114.—A large lode of calcspar is reported traversing these leases, with occasionally black oxide of copper.

"M.L. 121.—A large outcrop of blue and green carbonates and black oxide reported visible in this lease. A shaft 10 feet deep on a rich vein shows the latter rapidly increasing in width.

"M.L. 117, adjoining 118.—Bold outcrops of copper ore reported to be traversing this block, capable of being quarried.

"Adjoining 117.—A 20-acre lease has been taken up, covering a number of 'blows' of similar character and quality.

"M.Ls. 41 and 42, formerly known as the Cootra Mine, now the Wertago.—On these blocks outcrops stand out many feet above the surface, with blue and green carbonates and black oxides, for a width of from 60 to 100 feet wide. These outcrops are of lower grade than those further north, but easily available by quarrying.

"A large deposit of limestone is reported within a short distance, and abundant ironstone within 8 or 9 miles.

"M.Ls. 40 and 43 cover lodes exposed in small creeks falling from the range, showing carbonates and black oxide."

In connection with the above extracts from the Warden's report, it will be well to bear in mind the latter part of Mr. J. B. Jaquet's report quoted above, touching the deceptive appearance imparted to large outcrops of sandstone by the stainings of copper carbonates, arising from decomposition of a little disseminated copper pyrites. (See also Wertago Mine.)

Broken Hill Division.

Orient Mine, 2½ miles easterly from Silverton, parish Bray, county Yancowinna.—Inspector Carthew reports (P.B. $\frac{1}{0}\frac{4}{8}\frac{2}{8}$) copper vein in quartz; strike N. and S. Stoped from 80 feet to surface.

Paragon Lode, Waukeroo Paddock, 35 miles north of Broken Hill, near Gum Well Creek, parish Tarrowingee, county Farrel.—Inspector B. Sawyer reported (P.B. $\frac{2}{0}\frac{6}{7}\frac{7}{7}\frac{6}{7}$) a very strong quartz and calcite reef carrying copper carbonates along the outcrop runs through the lease. 16 tons of ore sent to Adelaide returned about 8 per cent. of copper.

Aid granted for 50 feet of sinking. Later it was reported that prospects were not so favourable.

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ALBERT MINING DISTRICT—*continued.*

Pinnacles.—The following particulars of copper lodes in this locality were obtained through the local Warden :—

"Several copper bearing outcrops occur within a radius of about 15 miles, the two most important and promising being one prospected by Messrs. Lord and party, about 4 miles west of Pinnacles. This outcrop is reported traceable for a considerable distance. Copper indications occur in it at intervals. Assays have yielded from a trace to 50 per cent. of copper.

"The second promising lode is situated about 2½ miles south-west of Pinnacles. It was opened about thirty years ago, and a consignment of copper ore is reported to have been despatched to Adelaide. This lode is stated to be strong in the outcrop and traceable for a considerable distance."

Ponto Mine, 15 miles from Morden Station, and 7 from Induna Park Hotel, on Broken Hill to Cobham road.—Inspector B. Sawyer reported (10th September, 1907) that a small company had been formed to work this lode, which is said to be of fair width. Shaft 102 feet driven 50 feet along the lode at 90-foot level.

Output, 50 tons of 18½ per cent. ore.

Purnamoota, 6 miles N.W. parish Robe, county Yancowinna.—Inspector J. Carthew reported (P.B. $\frac{8}{0}\frac{8}{7}\frac{3}{3}$) ore veins striking N.E. carrying copper, lead, and silver, traceable for about half a mile.

Aided to sink from 15 to 65 feet.

Seven miles N.W. of Purnamoota homestead, near Mount Robe, parish Lewis, county of Yancowinna.—Inspector J. Carthew reported (P.B. $\frac{8}{0}\frac{8}{7}\frac{7}{7}$) a vein striking N.W. carrying copper, lead, and silver. Apparently a continuation of the Mount Robe lode.

Aided to sink from 40 feet to 90 feet.

Purnamoota.—Messrs. Davison and Ayliffe reported through the Warden (1898) that good surface indications of copper occur in several localities in the neighbourhood of Purnamoota, but are of no great depth. At Terrible Dick very good specimens were obtained at surface, but carried down only 30 or 40 feet. Similar conditions prevail at the Paragon Mine.

Red Flag Copper Mine, 12 miles westerly from Broken Hill, parish Stephen, county Yancowinna.—Inspector J. Carthew reported (P.B. $\frac{1}{0}\frac{1}{5}\frac{0}{5}\frac{3}{3}$) copper lode in quartz; strike E. and W., dip. S. Payable ore stoped from 60-foot level to surface.

Aided to sink from 133 feet to 183 feet. At 146 feet copper vein about 9 inches thick in schist and iron oxide. At 154-foot vein 18 inches thick in eastern end of shaft; water troublesome. At 161 feet same thickness, dipping east (found impracticable to continue without machinery).

Rockwell Paddock, half a mile south of Rockwell Post Office, parish Sebastopol, county Yancowinna.—Inspector Hebbard reported (P.B. $\frac{3}{0}\frac{4}{0}\frac{0}{0}\frac{4}{4}$) copper, lead, and silver ores in mica, schist, and quartzite. At 71 feet proved poorer than at surface.

Ruby Copper Mine, about 10 miles from Broken Hill, just off Day Dream road.—Chief Inspector J. B. Jaquet reported[1] that the shoot of payable ore in this mine varies from a few inches to 1 foot 6 inches in thickness, and has a length of 60 feet. Shaft sunk 120 feet; 200 tons reported to have been despatched.

[1] Ann. Rept. Dept. Mines for 1901, p. 167.

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ALBERT MINING DISTRICT—*continued.*

Silverton.—The following particulars of copper lodes in the neighbourhood of Silverton were supplied to the local Warden by Mr. R. H. Srezise, under date July, 1898:—

"We first tried in the hills to the west of the Umberumberka Mine for four weeks, but abandoned the site after obtaining 30 cwt. of 10 per cent. copper ore in the time mentioned. We then tried in the hills on the east side, and succeeded in raising 10 tons of 11½ per cent. copper ore in eight days; but it proved only a pocket in a big lode formation, and as it cut out entirely at 9 feet, we abandoned this site also, and pegged out a third area about 2 miles north on the same line of lode. In twelve days we have raised about 9 tons of ore, averaging about 13 per cent., and are now sinking a shaft.

"Barron and party are obtaining good results from near Mount Robe. Several trucks of ore have been despatched, believed to contain 33 per cent. of copper.

"Near the old racecourse Casey and party are reported to be raising payable ore."

Two other parties were at work near the Old Silverton Copper Mine, one of which had despatched a parcel of ore, from which good results were anticipated.

Trinidad Copper Mine, 3 miles from Silverton, on Thackaringa-road, parish Bray, county Yancowinna.—Inspector Hebbard reported (P.B. $\frac{5}{8}\frac{1}{0}\frac{1}{0}$) copper ore in mica, schist, and diorite. Strike, N. 10° E.; dip, S. 80° E. Ore bands 3 to 15 inches wide.

Aided to continue 28-foot shaft to 78 feet. At 34 feet iron and copper stained schist. At 43 feet lode almost entirely pinched out.

White Cliffs Division.

Wertago Copper Mines, parish of Wertago, county Yungnulga, 70 miles N.W. of Wilcannia, and 100 N.E. of Broken Hill.—Chief Inspector J. B. Jaquet examined these deposits in 1901, from his report the following particulars are extracted:—

"Occurrence of copper ore at Wertago long known. Thirty years previously parcels of ore were despatched, but only since end of 1898 that much developmental work has been carried out, and public attention directed to the field.

"Dominant geological features, schists, quartzites, sandstones, and conglomerates of lower Silurian (?) age. These rocks are intruded by dykes of amphibolite and quartz felsite. Recent deposits of amorphous limestone, similar in character to those of Acacia Siding and elsewhere, in vicinity of Broken Hill, are found capping the older rocks in places.

"The copper ore occurs partly in well-defined lodes, and partly as detached bunches or pockets, which are found more or less in a line with one another along certain zones of country.

"Summary.—The field is capable of yielding considerable quantities of ore. There are two great obstacles which impede the progress of the mines; their isolated position, and the difficulty of obtaining an adequate and regular water supply. Only the very richest ores can be profitably carted 80 miles to the River Darling at Wilcannia. A reverberatory furnace was erected

[1] Ann. Rept. Dept. Mines for 1901, p. 168.

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some few months ago, and many tons of carbonate ore were reduced. Ironstone and limestone obtained locally were used as fluxes, and the fuel employed was wood.

"Smelting operations do not appear to have progressed favourably, and the furnace has been closed down for some time past. I am informed that less than 3 tons of copper were produced. I am not in a position to discuss, in detail, the circumstances which caused the enterprise to fail. However, it is apparent to anyone examining the various mines upon the field, that the ores hitherto discovered are chiefly of one kind—acid (silicious) carbonate ores. These ores could be best smelted in conjunction with basic sulphide ores, and it is probable that ores of this character will be found occurring beneath the zone of oxidation. Should it be decided to sink in search of sulphide ore, I would recommend that a site be selected upon a well-defined lode, such as that occurring in the Copper Well Mine, rather than upon an impregnated belt of country, where the ore is to be found in disconnected bunches, such as is the case in the Big Wertago and adjoining mines."

The principal mines will be found more fully described under their distinctive titles.

Block 118.—Mr. Jaquet, in the same report, states that a quarry 70 feet long has been opened along the side of a creek in this block, upon an ore body, from 2 to 3 feet wide, composed of schist impregnated with copper carbonates.

In Block 5, one-quarter of a mile N.E. of surveyed town of Robertson, parish of Wertago.—Inspector J. Carthew reported (P.B. $\frac{2}{0}\frac{6}{6}\frac{2}{2}$) ironstone and quartzite containing copper ores. Strike, N.E. in slate and schist. Prospects in 24-foot shaft encouraging, vein about 15 inches wide. Aided to sink to 100 feet.

Progress.—At 65 feet a few veins noticeable. At 71 feet work stopped by water. No immediate prospect of payable lode.

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BATHURST MINING DISTRICT.

Blayney Division.

Annandale South Copper Mine, M.L. 1.—First opened about twelve years ago under aid from the Prospecting Vote. At 80 feet carbonate of copper occurred. Shaft continued to 150 feet. Lode about 1 foot wide. Two or 3 tons of ore raised; picked samples reported to have yielded from 24 to 60 per cent. of copper.

About 10 chains S. 20° E. of the above, another shaft was sunk about 40 feet on a quartz reef carrying copper and iron pyrites; the former apparently increasing in proportion with depth. The oxidised ore at surface was reported to prospect about 8 dwt. of gold per ton; the sulphide about 8 per cent. of copper. The reef strikes N. 70° W. in andesite, and dips S. 70° W. Thickness at 40 feet, about 1 foot 6 inches.

Bathurst Division.

Apsley Copper Mine, parish Ponsonby, county Bathurst, about 5 miles from Perth Railway Station.—The earliest reference to this mine is contained in the "Mineral Statistics of New South Wales," 1875, p. 92. At that date it had been proved to a depth of 100 feet. Thickness of lode 3 feet to 5 feet. Strike north and south; dip easterly. Ore assaying from 4 to 18 per cent. of copper. 150 tons were being raised monthly and disposed of to the Esk Smelting Company, which had a reverberatory furnace running intermittently near by, the sale tariff being 85s. per ton for 10 per cent. ore, and rising 13s. per unit. Eighteen men employed.

The yield in 1876 is given as 20 tons of copper.

In 1877 the lode was traced further to the north. Operations during 1878 were confined to near the surface for carbonate ores; and continued so for the better part of 1879. During the latter part 60 tons of ore were raised, yielding 7 tons 16 cwt. of copper, valued at £429. In 1880 the mine changed hands, and continued in work without interruption. 191 tons of ore were raised and sold to the Bowenfels Smelting Works for £750.

In 1881 only 28 tons of ore were raised, producing 3½ tons of copper, value £220. Lode 6 inches thick in a 40-foot shaft. In this year the mine was reopened by Mr. Lewis Lloyd; but no further particulars are available of the result of operations. For many years it remained idle. In 1898 it was restarted; and in December of that year it was visited by the Writer. A new shaft had been sunk 186 feet, cross-cut east 30 feet to the lode on which a winze was sunk 63 feet following the slight underlay to the east; the course of the lode being about N. 20° E. At the bottom of the winze the lode was solid and about 9 feet wide. Hanging wall well defined, foot-wall broken. Lodestuff largely blende with chalcopyrite and pyrite. The ore raised during these prospecting operations was broken and sorted into "firsts," "seconds," and "waste," the "firsts" being despatched to Mr. L. Lloyd's Smelting Works at Lithgow; 38 tons yielded 7 per cent. of copper. A sample, 4302–98, yielded 7·93 per cent. copper; 16·53 per cent. zinc; and 2 oz. 7 dwt. 22 grs. of silver per ton. No gold. Country schist, partly hornblendic.

Subsequent Development.—In February, 1907, a syndicate, under management of T. K. Longton, secured control, and re-opened the main shaft. Operations were, however, suspended after a short period.

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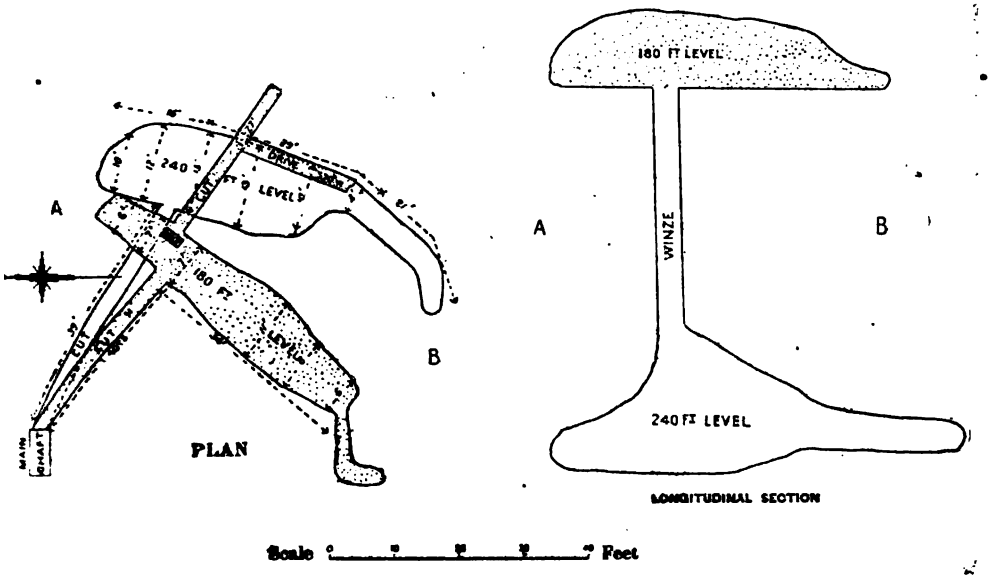
An option was then secured by Mr. Francis Drake, who unwatered the new shaft section to the lowest level attained, viz., 240 feet. The ore body exposed in the stopes at 180 feet and 240 feet was carefully sampled by Mr. J. F. Carey, with the following results :—

(*a*) Ore body at 180-foot level, over an exposed length of 45 feet, and a width of 5 feet to 10 feet, averaged 7·13 per cent. copper.

(*b*) In winze between 180-foot and 240-foot level, averaged 11·56 per cent. copper.

(*c*) Ore body exposed at 240-foot level, length 53 feet, width 7 feet 6 inches, averaged 7·92 per cent. copper.



Whilst the mine was unwatered a further inspection was made by the Writer on 5th December, 1907, and the following check samples taken :—

Average sample north end of stope, 180-foot level, 5 feet wide :—

No. $\frac{7940}{07}$	Copper	10·34 per cent.
	Gold	a trace per ton.
	Silver	3 oz. 5 dwt. 8 grs. per ton

Average sample from centre of ore-lens, 180-foot level, width 7 feet 9 inches :—

No. $\frac{7941}{07}$	Copper	6·36 per cent.
	Iron	16·24 ,,
	Zinc	8·88 ,,
	Sulphur	15·23 ,,
	Silica	24·06 ,,
	Gold	a trace per ton.
	Silver	2 oz. 14 dwt. 10 grs. per ton.

Average sample near south end of lens, 180-foot level, 5 feet wide :—

No. $\frac{7942}{07}$	Copper	3·52 per cent.
	Gold	a trace per ton.
	Silver	2 oz. 14 dwt. 10 grs. per ton.

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Average sample from south end of stope, 240-foot level. Width, 16 feet :—

No. $\frac{1}{57}\frac{2}{3}\frac{3}{2}$	Copper	5·51 per cent.
	Iron	22·82 ,,
	Zinc	8·25 ,,
	Sulphur	19·95 ,,
	Silica	16·55 ,,
	Gold	a trace per ton.
	Silver	2 oz. 0 dwt. 7 grs. per ton.

Average sample from north end of stope (240 feet level). Width, 10 feet :—

No. $\frac{1}{57}\frac{2}{3}\frac{3}{2}$	Copper	4·42 per cent.
	Iron	15·45 ,,
	Zinc	8·11 ,,
	Sulphur	11·30 ,,
	Silica	27·35 ,,
	Gold	a trace per ton.
	Silver	1 oz. 12 dwt. 16 grs. per ton.

The principal line of workings strike about N. 10° E., but another (western) intersects on a strike of N. 20° E. The provings—old shafts—extend for about 410 feet, and a width of 250 feet at the south end. Traces of copper carbonates are visible in the tips. Iron pyrites, cubical and granular, is also abundant owing to decomposition of the soft schist.

The ore occurs as impregnations in the schist, without definite boundaries. A cross-cut at 180 foot level in main shaft, after passing through the main ore lens, cut a 3-inch vein of ore ; beyond this ore is again showing in face of cross-cut. A sample of the 3-in. vein yielded :—

No. $\frac{1}{05}\frac{2}{8}\frac{3}{3}$	Copper	14·99 per cent.
	Zinc	1·82 ,,
	Iron	20·16 ,,
	Sulphur	18·58 ,,
	Silica	29·90 ,,
	Gold	a trace per ton.
	Silver	2 oz. 10 dwt. 2 grs. per ton.

The average results of independent sampling tests in the two levels, by the Writer and Mr. J. F. Carey, work out as follow :—

Mines Department assays, 180-foot level	=	7·13	per cent. copper.
J. F. Carey's ,, ,,	=	7·52	,, ,,
Mines Department assays, 240-foot level	=	5·09	,, ,,
J. F. Carey's ,, ,,	=	7·97	,, ,,

The Mines assays in the latter representing a width of 16 feet, against 7 ft. 6 in. for Mr. Carey's.

Similar tests at the north end of this level worked out at 4·42 and 5·95 per cent.

A solid block of ore exists between the two levels, which have only been stoped up a few feet.

The ore consists, where massive, of copper and iron pyrites and zinc-blende. In other parts of impregnated schist chiefly hornblendic. Water makes at the rate of about 2,200 gallons per twenty-four hours.

The furthest south-western ore occurrence proved in this property—327 feet from the main shaft, in a shaft 33 feet deep—is reported by Mr. Carey to yield an average of 6·25 per cent. of copper, from a width of 5 feet.

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Bathurst Mining District—*continued.*

Blayney Division.

Athole-Blayney Copper Mine, 2 miles south of Blayney.—Athole-Blayney Syndicate (No-liability) formed to prospect this deposit during recent copper boom. Shaft, 100 feet deep; trimmed down 7 ft. x 4 ft. in clear; driven northerly at 50-foot level for a distance of 40 feet; two shoots of ore reported to be showing in drive; about 20 tons raised; highest assay for check sale test, 21·4 per cent. of copper; ore reported in north end of shaft all down, and beginning to show in south end at 70 feet.

Rockley Division.

Balmoral Copper Mine M.Ls., parish Ponsonby, county Bathurst, between Belmore and Sugarloaf Mines, near Cow Flat, about 1 mile south of Belmore Mine.—Country micaceous and hornblendic schist and limestone.

Strike, N. 20° W.; dip, S. 70° W., at 50 to 58°. Opened in the days of Cow Flat smelting by shallow shafts; nothing known of early output.

Reopened by the Balmoral Syndicate about November, 1906. At date of inspection (6th December, 1907) shaft 155 feet deep, driven north from 150-foot level 40 feet and south 28 feet.

Width of ore followed about 3 feet, consisting of splashes and strings of copper pyrites in hornblendic schist, with blotches of calcite; zinc-blende not conspicuous.

Hanging wall, schist; footwall, limestone; evidently not true footwall; a short cross-cut into it revealed 2 feet of limestone, then strings of ore which are still showing in face, and should be further cross-cut.

The present owners have sent to Lithgow 8 tons dressed ore, which yielded 11 to 12 per cent. of copper; 5¼ tons dressed ore, which yielded 8 to 9 per cent. of copper.

Belmore Copper Mine, near Cow Flat, M.Ls. 25, 26, and 27, parish Ponsonby, county Bathurst, about 5 miles from George's Plains Railway Station.—The earliest official record of this mine is that by the Mining Registrar in 1875, to the effect that the mine was being worked by tributers with payable results. (Tributers were also at work on Messrs. Hulks and Co.'s property, 2 miles S.W. of Cow Flat, with advantage to themselves). In this year it is also recorded that Messrs. Croaker & Co. erected a smelting furnace about 1 mile from the Cow Flat Mine, and rented it to the Esk Smelting Company; this was probably identical with the furnace run by the latter near the Apsley Mine.

In 1877 payable sulphides were reported below the oxidised zone. In 1878 little work was being done, about 7 or 8 tons of ore per month only being raised. In this year the late Government Geologist, Mr. C. S. Wilkinson, visited the mine, and described the ore bodies as "small, irregular veins of copper ore in greenstone, at its junction with the Silurian Sedimentary Series."[1]

In 1879, 190 tons of ore were raised, and sold for £440. The ore at this time was reported to be too low grade for remunerative working at the low price of copper ruling.

In 1880, 172 tons of ore were raised, and sold for £317.

In 1881, 118½ tons of ore were raised, and sold for £163.

No further returns are obtainable. The deepest shaft was reported to have reached the 100-foot level.

[1] Ann. Rept. Dept. Mines for 1878, p. 150.

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BATHURST MINING DISTRICT—*continued*.

On 28th April, 1898, the *Australian Mining Standard* reported that the mine had been taken over by the Anglo-Australian Exploration Company, which proposed to re-open and prospect it.

In June, 1899, aid was granted from the Prospecting Vote to cross-cut at 90-foot level drive, 50 feet south.

Black slate and limestone in cross-cut; streaks of copper sulphide at end of drive; lode split by "blows" of limestone.

Further aid granted to continue shaft to 180 feet. Sinking through slate, limestone, and lodestuff; lode dipped west, just showing in shaft at 130 feet; a little copper sulphide occasionally met during progress.

Examined by the Writer in the same year. Lode strikes N.E. and S.W. in hornblende and micaceous schist, in close proximity to limestone. In the New Belmore shaft, the lode appears to strike N. 40° E., and to dip N. 50° W. About 12 feet of lodestuff, much mixed with country and quartz exposed in workings; concentrating material.

In 1901, small blast furnace erected; about 620 tons of about 3 per cent. ore smelted. (Ann. Rept., 1901, p. 54.)

Four hundred and fifty-six tons of ore were raised during 1902 (*ibid.*, 1902, p. 49.) Re-opened in March, 1905; 140-foot shaft retimbered; reverberatory erected (*ibid.*, 1905, p. 45).

Prospecting continued in 1906 from old shaft, a little ore proved for a considerable width in strings and bunches in limestone and hornblende schist; its distribution increasing cost of production.

In 1907, 52 tons of dressed ore obtained whilst sinking new shaft to a depth of 200 feet, which was sold at a profit, at Lithgow. Work ceased during year.

During operations from October, 1905, to cessation in 1907, 188 tons of dressed ore were disposed of for a return of 12½ tons of copper, equal to 6·6 per cent. in the ore.

Canowindra Division.

Belubula Copper Mine, portions 4 and 5, parish Malongulli, county Bathurst, Licking Hole Creek, about 16 miles from Canowindra.—The late Mr. W. M. Rothery, of Cliefden Station, informed the Writer that in 1845, or earlier, copper ore was discovered outcropping on portions 2 and 3, adjoining those abovementioned, but as nothing defined was found below the surface indications, attention was directed to the site of the above mine on Cliefden pre-emptive lease, and portions 4 and 5 were purchased by Messrs. Want and Donaldson. Extensive prospecting operations were carried out, the main shaft reaching the 84-fathom (504 feet) level, and drives were extended at various levels. Mr. Rothery, who acted as paymaster for the proprietors, stated that absolutely nothing beyond traces of copper were ever discovered. Ores purporting to be from this mine according to the catalogue were exhibited at the Paris Exhibition of 1855.[1]

Rockley Division.

Black Mountain Mine, portion 29, parish Arkell, county Westmoreland.—Opened in early days of western copper mining. Strike, north 50° west, with a flat dip at about 25° south 40° west.

At surface a thin bed—about 2 feet—of chlorite schist in decomposing liberates copper carbonates as stains in the foliation. In sinking on this following the underlay, it pinched out between quartzite foot and hanging walls. The latter was driven through for some distance to the bottom of the

[1] See pp. 274, 275.

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General View, Blayney Copper Mines and Smelting Works, March, 1908.

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present shaft—about 150 feet—where a little softer rock is showing, carrying a little pyrites and faint splashes of copper sulphide. No defined ore body.

A small bunch of carbonate ore was worked out near surface, by McGregor and party, about 1899. Thirteen tons sent away are reported to have yielded 10 to 13 per cent. of copper.

A sample of the ore at grass from recent operations yielded—

No. $\frac{8}{99}$—Copper, 7·42 per cent.
Gold, a trace.
Silver, 13 dwt. 1 gr. } per ton.

Blayney Division.

Blayney Copper Mine (formerly *Annandale*).—This mine, at which operations have been recently renewed, is situated on a part of the Marsden Estate, close to the town of Blayney. The Blayney to Harden Railway line passes within a few yards of the mine, which possesses a private siding. The lode occurs in andesite, and is of considerable width. Over 2,000 tons of iron oxide are reported to have been quarried from the outcrop for the Lithgow Iron Smelting Works before any trace of copper was discovered.

In 1881 traces of copper ore were exposed in a small quartz vein. In following it down a little copper ore was met at 90 feet from the surface. The mine was then taken on trial by Sydney investors, and subsequently purchased by them for £10,000.

The Great Blayney Copper Mining Company was then formed (in 1882), and smelting works erected. At 110 feet the lode was proved 40 feet wide. The deepest shaft was sunk nearly 300 feet. Unfortunately, particulars of the early operations are not obtainable; work was, however, not continued for any length of time.

In 1889, under the name of the Annandale, the mine was again worked with reported fair results, the company operating being a small one. A furnace was erected at this time, according to the local Mining Registrar, on a new principle, which, however, was unsuccessful, and another had to be erected in its place. At this date several shafts had been sunk on the lode, ranging from 110 to 292 feet, well prospecting the lode to that depth. Six tons of copper were produced, realising £57 10s. per ton.

In 1891 it was reported that the mine was shut down, owing to the low price of copper and the low grade of the ore.

In 1892, 10 tons of copper were produced, valued at £435.

The mine then remained idle until 1897, when it was again taken up by a syndicate, who began unwatering it. After nearly twelve months' baling by kibble, the water was lowered sufficiently to allow of ore being stoped at the 90-foot level for trial smeltings. The ore from this level—just below the zone of oxidation—consisted of magnetic iron pyrites and chalcopyrite, which was roasted slightly in heaps and then smelted in reverberatories without flux, as a fair percentage of lime (calcite) occurs in the ore.

The magnetic pyrites (pyrrhotite) possesses the deceptive appearance of flesh-coloured copper sulphide, and this resemblance gave an inflated idea of its true value. A massive sample of the mineral was tested in the Departmental laboratory for gold, silver, and nickel, but none of these metals were detected; copper was only present to the extent of 0·22 per cent. The

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curious fact that pyrrhotite, though often rich in copper pyrites and nickel, rarely carries more than traces of gold has already been mentioned in this work.

Smelting operations were begun in 1898 in two reverberatory furnaces erected by the previous company, the second consignment of copper being despatched in May.

In July it was announced that a public company had been formed with a capital of £100,000, and that two water-jacket blast furnaces were to be erected.

The mine was visited in June and December of 1898. At the first date the 90-foot level of one shaft only was open for inspection. The walls and surfaces of the old workings were glistening with copper sulphate and in some places with fine crystals of native copper deposited from solution during flooding of the workings.

In December no fresh features had been developed in the mine, active operations so far as stoping and smelting were concerned having ceased pending the erection of the new haulage, pumping, and smelting plants. The two first were already nearing completion, and the foundations were being prepared for the latter.

A shaft (180 feet deep) in the east wall of the lode, started by the previous owners, was converted into the main shaft of the new company; substantial poppet-heads being erected, whilst prospecting operations proceeded by means of a small portable engine. A cross-cut then being driven from the 180-foot level had already pierced 30 feet of lodestuff, according to Captain Cock.

There is little question that such of the lodestuff as had been exposed at the 90-foot level was suitable for blast-furnace treatment at a low cost, the grade, however, is undeniably very low. If, as is surmised, the ore is of a kindly smelting nature, it behoves the proprietary to ascertain the amount of silicious flux—if any—that it can safely absorb, and if appreciable, to endeavour to secure gold and silver bearing ores for the purpose. If the Blayney lode should prove a fluxing base—like Cobar—the natura poverty of the ore would be counterbalanced by the possibilities opened up for spirited enterprise in connection with silicious, refractory, and low-grade gold and silver ores of the surrounding mining districts approachable by rail. It might also be the means of opening up the old copper lodes around Byng and Lewis Ponds, some of which would probably afford remunerative employment for small parties, if the dressed ore could be disposed of in the district.

The numerous small copper veins and lodes of the Carcoar and Woodstock districts might also profit by the erection of a central smelting plant at Blayney.

Recent Development.—In full work during 1900, but operations considerably reduced at end of year pending more extensive exploration of the lode. The value of the copper produced during the year was estimated at £40,250.[1]

During 1901 18,666 tons of ore were raised, which yielded 418 tons of copper. A second blast-furnace erected. Mine closed towards end of year.[2]

In January, 1907, the present Blayney Copper Mines and Smelting Company, N.L., was incorporated. The blast furnaces were renovated, and smelting began on the 25th July on about 2,000 tons of purchased ores.

[1] Ann. Rept. Dept. Mines for 1900, p. 54. [2] *Ibid.* 1901, p. 54.

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Winch converted into a Shell of Copper, Blayney Copper Mine.

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It having been ascertained that the mine water warranted construction of precipitating vats for recovery of copper in solution, a plant was laid down before baling began. The result has been phenomenal, a recovery of 39·65 to 43·5 lb. of copper per 1,000 gallons being obtained Wire scrap from Lysaght's wire works being used to advantage for precipitation, the recovery reaching 90 per cent. 67½ tons of cement copper were obtained from 4,600,000 gallons of water, this product being purchased by the Great Cobar, Limited.

At commencement of baling the mine water stood 80 feet from surface. The cause of its enrichment is the large extent of very low grade ores undergoing the process of decomposition or oxidation at and about water level. The early open excavations of the irony outcrop for smelting purposes at the first Lithgow ironworks, moreover, greatly aided the process of leaching by catching the rainfall and drainage and leading it down through the sphere of decomposition by numerous extensive cracks caused by subsidence. If the mine was permanently unwatered below the true water-level, the copper in solution would probably be insignificant. On the other hand, failing profitable mining developments below water level, the natural process of leaching above it can be successfully utilised at intervals by allowing the water to accumulate.

The lode occurs near the junction of augite andesite and Silurian Sedimentaries. Strike N.W. and dip N.E. Part of the channel rock is a highly crushed and sheared igneous rock of schistose appearance, probably the altered selvage of the intrusive andesite.

The lode has been proved for about 680 feet in length and 337 feet in depth, the lowest level being 277 feet, below which a winze has been sunk to the recorded depth.

So far as unwatering has proceeded below the 277-foot level, little workable ore has been exposed. The massive pyrrhotite at the 90-foot level in the south-western shaft, previously mentioned by the Writer as a kindly flux, was apparently not extensive. As far as inspection is possible at the present time, no massive pyritic ore, even of low grade, is in sight.

It is highly desirable that the Company, which is laying down an extensive Customs smelting plant, embracing gold and silver concentrates, should at least have command of abundant basic flux even if of low copper value.

The plant consists of two blast-furnaces, each of a nominal capacity of 120 tons; a converter plant—the first in New South Wales; and a small cupola for matte melting.

A large reverberatory furnace and an Edwards' roaster are in process of construction. The mine and works are connected with the State railway system.

A satisfactory trial run of the converter has been made, the linings being formed of crushed auriferous quartz, with sufficient local clay to bind it. Small compressor rammers are used in lining.

Limestone flux is obtained from a lease on private land about 1 mile distant; firebrick from J. Dewar, Bathurst; and coke from Bulli.

The following description of the Company's smelting plant has been furnished by the General Manager, Mr. F. L. Piddington:—

Blayney Copper Mines and Smelting Company, N.L.

The smelting plant of this Company comprises two blast furnaces, a converter plant, and Edwards' roasting furnace, and a reverberatory smelter, the two latter in course of construction.

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The blast furnaces are 168 inches by 40 inches at tuyere level, and 9 feet high from tuyeres to downtake flue which is taken off below the feed floor. There are thirty-two tuyeres each 3 inches in diameter. Blast is supplied by two No. 7 Roots' blowers direct coupled to horizontal engines by Fraser and Chalmers.

The converters are of the Leghorn type 8 feet long by 6 feet diameter, fitted with patent ball valves. The turning gear is actuated by two speed Westinghouse motor with reversing switch. The matte remelting cupola is 36 inches diameter, and is tapped direct to a 5-ton ladle handled by 20-ton travelling crane. Linings are crushed in a 6-foot Chilian mill, driven by motor. Blast for the converters is supplied by horizontal compressor 12-inch steam cylinder 30-inch air by 24-inch stroke fitted with spring valves of the Rand type. Its capacity is 2,500 cubic feet free air per minute at a pressure of 15 lb. per square inch.

Power for motors and lights is supplied by 60 k.w. Parker generator direct coupled to Alley and McLellan engine. Steam for generator and compressor is provided by a four-drum Stirling boiler, 230 nominal h.p.

The Company has its own railway siding on which is installed a 20-ton Avery scales. The Sampling Mill is equipped with No. 3 Dodge breaker, and one set 14-inch by 7-inch Roger rolls together with sample grinder, and the usual bucking plates.

The storage bins for ores, fluxes, and fuel have a capacity of 3,500 tons.

Blayney (*See* Blayney, South Annandale, Wright and Osborne's, and Quigley's Hill Mines.)

On Stinson's property, west of the cemetery, a copper lode was opened to a depth of 60 feet, its thickness being 3 feet. About £300 worth of ore is reported to have been despatched from this lode to the Lithgow Smelting Works.

On Glasson's properties, and Clauson's, close to Blayney, a little copper ore has also been discovered.

Orange Division.

Bob's Mount.—Emu Swamp, Springfield Estate, between Orange and Lewis Ponds. Copper ore originally discovered by R. Atkins. First shaft sunk by T. Payne, about 1899. The lode traverses the southern slope of Bob's Mount, on a north 10° west strike, and was intersected by a 140-foot cross-cut tunnel from the level of Emu Swamp, about 120 feet below the highest outcrop, where a shaft was being sunk.

Where the tunnel cut the lode but a few feet of backs occur owing to the slope of the hill. A few feet from the intersection a winze was sunk 15 feet in the lode, and from this level the lode was driven on northerly for 280 feet. At time of inspection (February, 1908) water was standing almost level with the top of the level, work being concentrated on the shaft. As the latter is to be connected with the tunnel the surface water to that level only will be drained; pumping or baling will still have to be faced when the lower levels are attacked.

From the tunnel level a total of 127 tons of ore were despatched after hand dressing for an average yield of 10 per cent. of copper.

The ore sunk in the shaft is of a highly silicious nature. An average sample yielded:—

No. $\frac{5}{0}\frac{7}{8}\frac{2}{}$—Copper	9·85 per cent.	
Gold	a trace.	per ton.
Silver	1 oz. 14 dwt. 20 grs.	

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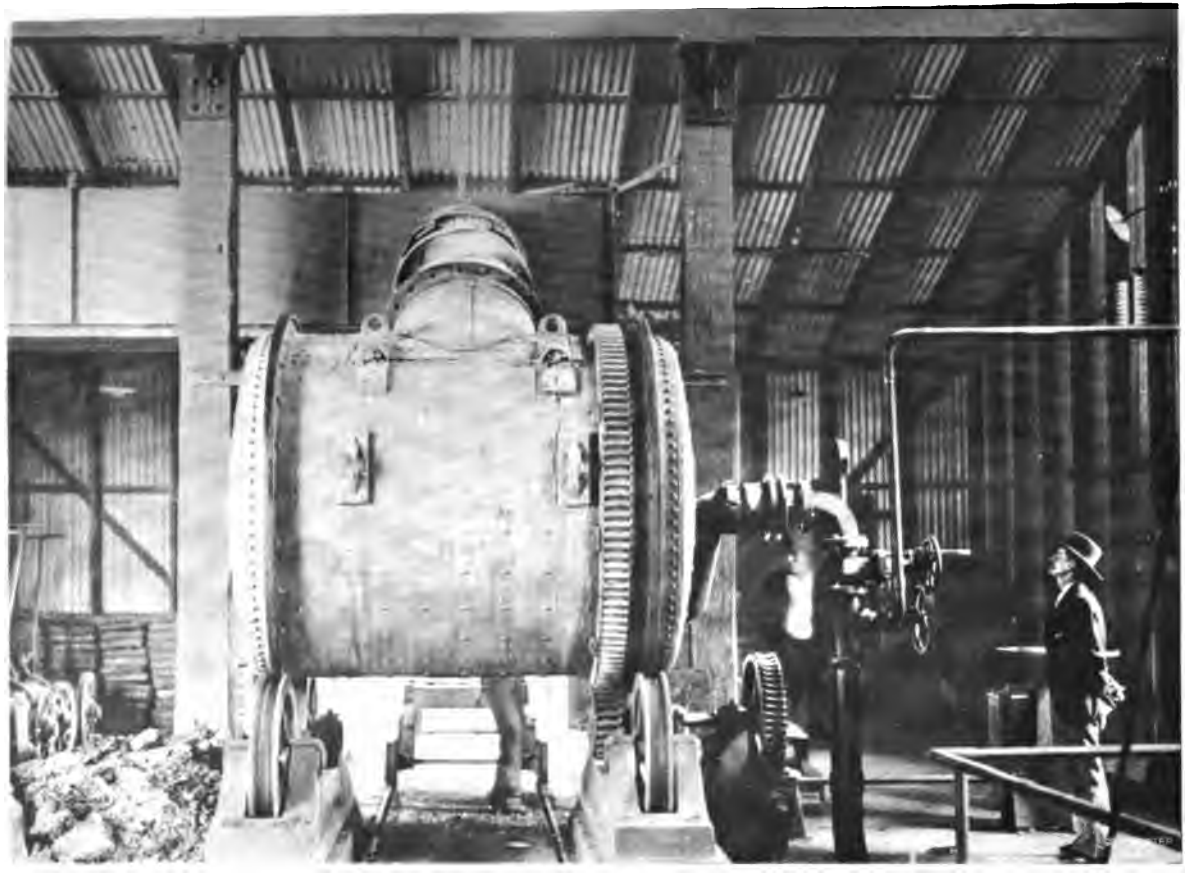

Converter Plant, Blayney Mines and Smelting Works, March, 1908.

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Bathurst Mining District—*continued.*

Britannia Mine, M.L. 10, parish Worcester, county Bathurst, near Lewis Ponds, close to Bell Mount.—Worked by the Great Western Copper Mining Syndicate in 1872. At present held by H. B. Thomas and party. No record of old workings other than a brief record of depth and thickness of lode. Captain W. R. Reynolds informed the Writer in 1898 that it was worked to the 210-foot level, and that the thickness varied from 3 to 5 feet.

Two lodes appear to junction in this lease, the Britannia striking north-west, and another north 10 degrees west. If the latter is persistent so far, it should intersect the main line in the old workings. These, however, are not now open to inspection. The latter extend for a distance of about 260 feet.

Present efforts are confined to testing the northern and southern extension of the lode.

A few chains north of the old Britannia workings, a shaft has been sunk 60 feet on the lode, which here consists of soft, partially enriched sulphides, of a reported width of 12 feet, a few tons of which have been raised in sinking. The quality of this ore is shown by the following assay :—

No. $\frac{5}{0}\frac{7}{8}$—Copper, 18·93 per cent.
Gold, a trace per ton.
Silver, 1 oz. 1 dwt. 19 grs. per ton.

At the southern end, 65 feet from the old workings, a shallow shaft (not in ore) has been deepened from 50 to 60 feet. At 53 feet on a south-west dip, sulphide ore began to make in the southern end of shaft. Its quality is revealed in the following assay :—

No. $\frac{5}{0}\frac{7}{8}$—Copper, 21·10 per cent.
Gold, a trace per ton.
Silver, 1 oz. 10 dwt. 11 grs. per ton.

Persistence and quantity have yet to be proved.

In the shaft (80 feet deep), sunk by the Noller Mining Syndicate on the flank of Bell Mount in the intersecting lode, copper carbonates were struck at 25 feet in an 8-inch vein. At 80 feet it was driven on south for 20 feet. Further south are old workings from which good ore is reported to have been raised in the early days of the field.

An average sample of the ore gave the following returns :—

No. $\frac{4}{0}\frac{7}{8}$—Copper, 21·48 per cent.
Gold, a trace per ton.
Silver, 16 dwt. 8 grs. per ton.

The Noller Syndicate obtained 9 tons of ore in sinking the 80-foot shaft, 6 of which yielded 15 per cent. of copper, and 3 tons 20 per cent. About 2 tons of dressed ore at grass represented by assay No. 574.

Rockley Division.

Brown's Creek, about 10 miles north-west of Rockley, adjoining Prosser's mine on south side at junction of Brown's and Edward's Creeks, parish Ponsonby, county Bathurst.—Inspector Hooke reported (P.B. $\frac{2}{0}\frac{8}{7}\frac{4}{2}$) a quartz reef in slate showing copper carbonate stains and small blebs of yellow ore.

Aided to sink 28-foot shaft to 78 feet following lode.

Brown's Creek, near Back Creek, Rockley, parish Ponsonby, county Bathurst.—Inspector Hooke reported (P.B. $\frac{2}{0}\frac{3}{8}\frac{2}{9}$) copper-bearing veins in chlorite schist. Aided to sink to 150 feet and cross-cut 60 feet, but subsequently altered to cross-cut at 80 feet.

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Progress: At 112 feet country very hard; formation serpentine with calcite streaks.

Three shafts had been sunk in bed of Brown's Creek, 30 feet, 110 feet, and 90 feet where lode outcropped. From one shaft a cross-cut under bed of creek cut lode formation with streaks of copper ore—not payable.

Aid granted to drive along course of lode. Copper veins showed no improvement, being thin, with bunches.

Copper ore in slate country also reported by the same officer on N. Wilson's improvement lease, close to the north boundary of Hill View Estate (P.B. $\frac{4}{99}\frac{8}{99}\frac{8}{99}$).

Oberon Division.

Bull's Creek, parish Jenolan, county Westmoreland.—Copper ore (bornite) occurs about 1 mile north of portion 5, on Bull's Creek, also about 1½ mile south of the same portion on the same creek, near its junction with the Jenolan River. Shafts have been sunk on both outcrops. The ore occurs in chlorite in very rich, small bunches, assaying up to 37 per cent. copper.

Cowra Division.

Burley Jacky Copper Mine, situated on the Redfern Estate, about 4 miles from Woodstock Railway Station, on the Blayney to Harden Railway.—The following particulars were supplied by Mr. Hemsley, of Blayney:—Burley Jacky lode was discovered in 1877. Two waggon loads (about 12 tons) were sent to Cadia Smelting Works, near the Canoblas; this apparently exhausted the ore in sight, for nothing more seems to have been done in the way of raising ore until 1890, when a very rich bunch of copper sulphide (bornite) was discovered upwards of 30 feet in width, and of an equal length. This chute was followed to the 230-foot level, when it cut out. The ore averaged 30 per cent. at the English and Australian Smelting Works, Waratah, and is stated to have realised a net return of about £47,000.

The lode occurs in andesite at the junction of sedimentary rocks. The lode channel is filled with boulders of andesite of all sizes up to several tons. Between the boulders, soft, crushed, or clayey filling occurs, stained with copper carbonates and containing bornite in bunches. The main bunch was cut off northerly by a cross joint in the andesite. Since the exhaustion of the rich ore chute, attention has been directed to the outcrop further north. Very kindly gossan occurs both at the main workings and at the northern extension, several chains distant. Several shafts have been sunk hereabouts in promising gossany carbonates with red jasper and chalcedony. The mine requires a deep test with adequate levels along its course. The richer (secondary) ores are likely to occur in isolated bunches, such as already discovered, but at greater depths the original yellow sulphide may prove to be more equally distributed in the lode. The rich and profitable chute already describedwas found only a few feet below the original workings after the mine had long remained idle. Two other lodes were discovered in the property during 1898; the furthest west, half a mile from the main lode, was opened to 70 feet. The lodestuff, 2 ft. 6 in. thick, consisted of quartz with copper sulphide, but not rich enough to bear cost of carriage and treatment. Gold is reported to have equalled 2 oz. to the ton of metallic copper; a sample of bornite, taken at random, yielded but a trace (under 2 dwt.) of gold per ton, and 9 oz. 14 dwt. 4 grs. of silver per ton. It does not appear that the owners derived any benefit from the presence of the

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General View of Works, Lloyd Copper Mine, Burraga.

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precious metals. About three-quarters of a mile northerly from Burley Jacky Mine, on the adjoining land, a little copper carbonate is showing in the andesite, and in a quartz reef some evidence of early superficial testing is apparent. From Burley Jacky several parcels of ore were raised and treated at Lithgow since previous inspection.

Burraga Division.

Burraga or Lloyd Copper Mine (formerly *Thompson's Creek Mine*).[1]—According to Mr. T. Russell, of Blayney, brother of one of the original proprietors, the Burraga Mine was discovered by a shepherd named McIntyre prior to 1877, taken up by Mr. Brownlow, of Briar Park, and transferred by him to Messrs. Russell and Clarke. The lode is reported to have been very thin at surface, with very little gossan. At 18 feet it opened out to a width of 18 feet of black ore, equal to 19 per cent. copper.

The following report was furnished to the Warden in ($\frac{1}{p.}\frac{8}{61}\frac{7}{8}$), by Messrs. Russell & Co.:—"We commenced work on the 3rd January last with two men, and now employ thirty-three, including teamsters. Clarke's shaft is sunk to a depth of 62 feet. The lode in this shaft is about 8 feet wide from the bottom to near the surface of 20 per cent. ores. The lode is disordered at the bottom of this shaft, this being the place of junction with an east and west and north and south lodes. The lode going south from this shaft is about 4 feet wide of black and yellow ore, and is continuous to No. 1 shaft north.

"No. 1 shaft is 40 feet deep, the lode being from 2 to 3 feet wide of yellow ore. Other prospecting has been done further north with good prospects."

From Clarke's shaft a drive was put in on the east and west lode, which was reported about 8 feet wide of yellow ore. Shaft No. 1 east was sunk 57 feet in a strong lode of sulphides. At the eastern end red oxide was reported. The last parcel of ore sold from this lode gave 43⅛ per cent. copper. No. 2 shaft, 60 feet, in yellow ore at bottom. No. 3 shaft, 60 feet, lode 5 feet wide; value, 22 to 26 per cent. (Extracts from Russell & Co.'s report.)

The ore was at this time being carted by teams to the Cow Flat smelters at a cost of 35s. per ton.

In 1879 work was continued, but the want of local smelting furnaces was militating against the development of the mine. Subsequently it passed into the hands of Mr. Lewis Lloyd, who had erected smelting and refining works at Lithgow, on the Western Railway line.

In 1880 the erection of reverberatories at the mine was commenced, the ore meanwhile going to the Lithgow works, 427 tons being raised and despatched during the year.

In 1881 the mine was in full work. The original name of Thompson's Creek Mine was in this year altered to Burraga. Four reverberatory furnaces were in full work and three others were in course of erection. One hundred and ten men were employed, 2,500 tons of ore being raised, producing 250 tons of refined copper, valued at £16,000.

The method then adopted is still in force, viz., reducing the ore to regulus of about 40 per cent. grade and refining at Lithgow, where coal and fireclay and easy freightage to market are available. The regulus is carted to Perth Railway Station, a distance of about 40 miles.

1 Parish Jeremy, County Georgiana. Height above sea level, 3,400 feet.

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In $\frac{1882}{p.\ 39}$, the Mining Registrar reported that 200 men were employed. Five furnaces were in full work. The output reached 4,450 tons, yielding 465 tons of copper, valued at £32,550.

The depth of main shaft, 180 feet; deepest level, 170 feet; width of lode, 7 feet. Population, about 400.

In 1883, 6,150 tons of ore were raised, producing 520 tons of copper, valued at £36,400.

In 1884 the only particulars given were that 582 tons of copper had been produced, which at previous valuation (£70 per ton) would equal £40,740, but this figure is obviously in excess, as the average market value (London) for this year was but £54 15s. 6d. according to H. Merton & Co.

In 1885 work was continued, the lode being reported as rich as ever at the 228-foot level, with a thickness of 6 feet. One hundred and fifty men were employed and 4,215 tons of ore raised, producing 440 tons of copper, valued at £22,500, or about £50 per ton.

In 1886 work was suspended owing to the low price of copper (averaging £40 6s. according to the above authority). For the nine months ending 30th September, 281 tons of copper were produced, valued at £14,000.

After being closed for twelve months, the mine was reopened in September, 1887; during the rest of the year 120 tons of copper were produced, valued at £7,500.

During 1888 operations continued in full swing, 499 tons of copper being produced, valued at £36,000. (Copper in this year experiencing a great rise owing to the operations of a French syndicate, the average value reaching £76 per ton.) The lode at 300 feet was reported to be 15 feet wide; 170 men were employed.

In 1889 the mine was shut down for six or seven months; afterwards 300 men were employed, but no returns are available.

Full work continued in 1890, 420 tons of copper being produced, valued at £24,150.

At the end of 1891 all but six hands were discharged owing to the low price of copper, the average market value having fallen to £51 3s. during the year. Returns of copper were not given for this year. Furnaces reducing ores at grass.

In 1892, 800 tons of ore were raised, but not all smelted. Eighty tons of copper were produced, valued at £3,600.

In 1893 the mine was idle until November, when 150 men were employed. The deepest level at this date being 750 feet; lode, 9 feet wide and improving.

During 1894 full work continued, 622 tons of copper being produced, valued at £24,800 = £40 per ton.

In 1895 work continued, with the exception of a brief interval in June, when the lode was lost; when recovered it was less rich than hitherto. This fact, combined with a labour dispute, reduced the output of ore to 3,311 tons, producing 331 tons of copper, valued at £14,895.

The output during 1896 amounted to 424 tons of copper, valued at £19,928 (£47 per ton), evidencing a rising market. One hundred and fifty men employed.

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BATHURST MINING DISTRICT—*continued*.

In 1897 the mine was worked full time, 150 hands being employed; 8,907 tons of ore were raised; estimated value of copper sold, £34,896.

During 1898, 8,518 tons of ore were raised, 5,678 tons were smelted for 570 tons of copper, valued at £28,500. The balance, 2,840 tons of seconds, being estimated to contain 142 tons of copper. One hundred and fifty men employed.

In 1899 the mine was purchased by the Lloyd Copper Company for £100,000.

The initial stages of this Company's operations were characterised by absence of foresight and ill-advised expenditure, which have seriously handicapped subsequent developments.

The first, unaccountable oversight was failure to recognise the importance of securing the adjoining property when purchasing the mine. The second, adoption of blast-furnace treatment at enormous outlay for unsuitable ore. The third, disregarding natural physical advantages for gravity handling from mine to tailing and slag dumps.

The adjoining property was secured in 1905, at a cost enhanced by the company's own outlay. Of the abortive reduction plant, little remains but an imposing stack of bricks and unremunerative expenditure.

The third defect is still painfully evident; the crude ore is shot down one incline, apparently for the purpose of hauling it up another to the mill, from the lowest floor of which the dressed material is again hauled upwards to the roasting plant.

The extra cost of avoidable haulage is a serious handicap entailed upon the present management in view of mining difficulties, low ore tenor, and depreciating fuel supply; though it enhances the credit of profitable working, even under these disabilities. Lloyd copper (including refining at Lithgow) has been delivered, f.o.b. Sydney, at a cost as low as £48 15s. per ton; which, for an extraction of about 2·5 per cent. from concentrating ore, is believed to constitute a record when the table of working costs is studied. In this connection, the following extracts from the Annual Reports of the Company for the years ending 30th June, 1905, to 30th June, 1907, are of interest:—

During the year ending 30th June, 1905, the output was considerably curtailed owing to prospecting alone being carried on for five months of the year. 37,518 tons of ore yielded 919·5 tons of copper, equivalent to 2·45 per cent. Even at this low percentage, the mine paid working costs and for five months' prospecting.

Working costs—including management, office, general expenses, leases, insurance, &c.—for seven months' operations worked out at £1 5s. 3·65d. per ton of ore; and the cost to produce copper at £51 12s. 6·06d. per ton. The total costs for the year (covering prospecting and development during suspension of treatment) worked out at £1 7s. 5·63d. per ton of ore; and the production of copper at £56 0s. 10·12d. per ton.

The manager estimated that with 1 per cent. higher recovery the costs would work out at £40 and £44.

For the year ending June, 1906, 59,641 tons were treated for 970 tons of copper—equivalent to an extraction of 1·62 per cent. The cost of producing

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copper for ten months amounted to £61 16s. 2d. per ton, owing to the extremely low grade of material treated. Higher grade having been obtained from the adjoining property (Hockey's) recently acquired, the cost of production for the last two months was reduced to £49 2s. 1d. per ton. For the twelfth month, the cost was £48 15s.

Working costs (as above) amounted to £1 0s. 6·6d. per ton of ore.

For the year ending 30th June, 1907, 58,159 tons were treated for 1,374 tons of copper—equivalent to 2·36 per cent.

Working costs were increased by amount of dead work involved by fault displacement to £1 7s. 1·28d. per ton of ore. Detailed expenditure being as follows :—

	£	s.	d.
Mining, including transport to mill	0	11	4·9
Concentrating, including tranfer to calciner	0	5	2·8
Calcining concentrates, and picked ore	0	1	4·8
Smelting calcined concentrates and stalled ore to matte	0	3	8·5
Roasting matte at Burraga	0	1	1·5
Roasting blister copper and matte at Eskbank, and refining same	0	1	8·4
Freight and f.o.b. charges, Sydney (road, 40 miles; rail, 150 miles)	0	1	5·4
Ore purchased at Eskbank	0	0	5·8
	£1	6	6·5
Mine development work	0	0	6·7
	£1	7	1·2

The average cost of producing refined copper, f.o.b. Sydney, was £56 3s. 8d. per ton.

The working costs are increased by the very flat dip of the lode, amounting on an average to only about 25 degrees from the horizontal. Handling ore in the stopes between levels is thus not facilitated by gravity.

Miners descend and ascend by walking; the lowest level, No. 14 (2,135 feet from the brace), is but 705 feet vertically below it.

The width of the lode varies from a few inches to 10, 20, or even 40 feet in places. Its special feature is its cutting across the stratification of the country without defined "walls" or other evidence of fissuring, the ore dying away in the country without definite boundaries. It appears as an impregnation, and in the larger makes as replacement. Possibly this mode of deposition accounts for the obliteration of the actual fissuring or line of weakness along which investing mineral solutions percolated, and wholly or partially saturated and replaced the country for varying distances from the circulating medium; the latter depending on the relative degree of permeability of the different strata encountered.

The lode being antecedent to the faulting encountered, the latter has no influence on its persistence. Denudation limits its western extension until lower levels are reached. Eastward, reversal of dip of the country takes place, viz., from east to west, forming a shallow syncline. Hence it is not unreasonable to anticipate connection between the ore body worked in the Burraga Mine and that opened in the east shaft over 3,000 feet distant.

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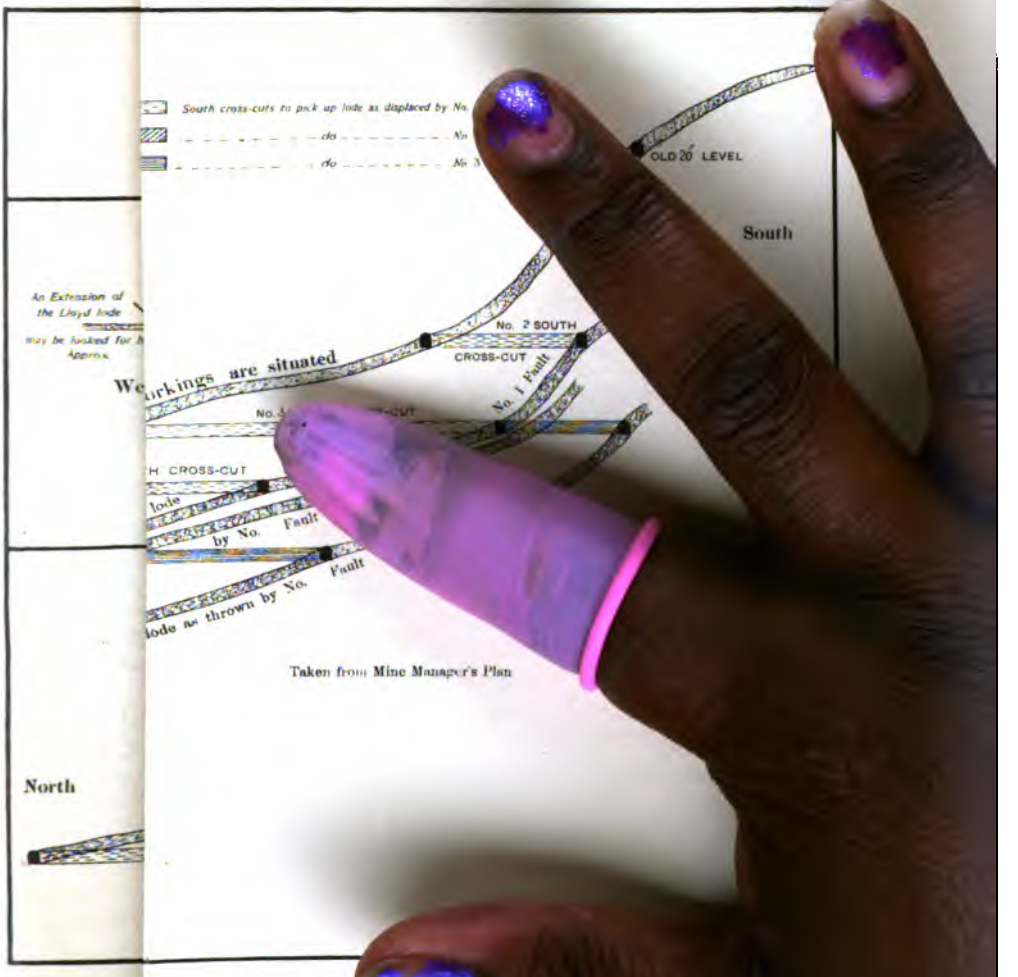
South cross-cuts to pick up lode as displaced by No.
do No.
do No. 3
OLD 20' LEVEL
South
An Extension of the Lloyd lode may be looked for h Approx.
No. 2 SOUTH CROSS-CUT
No. 1 Fault
H CROSS-CUT
lode
by No. Fault
lode as thrown by No. Fault
Taken from Mine Manager's Plan
North

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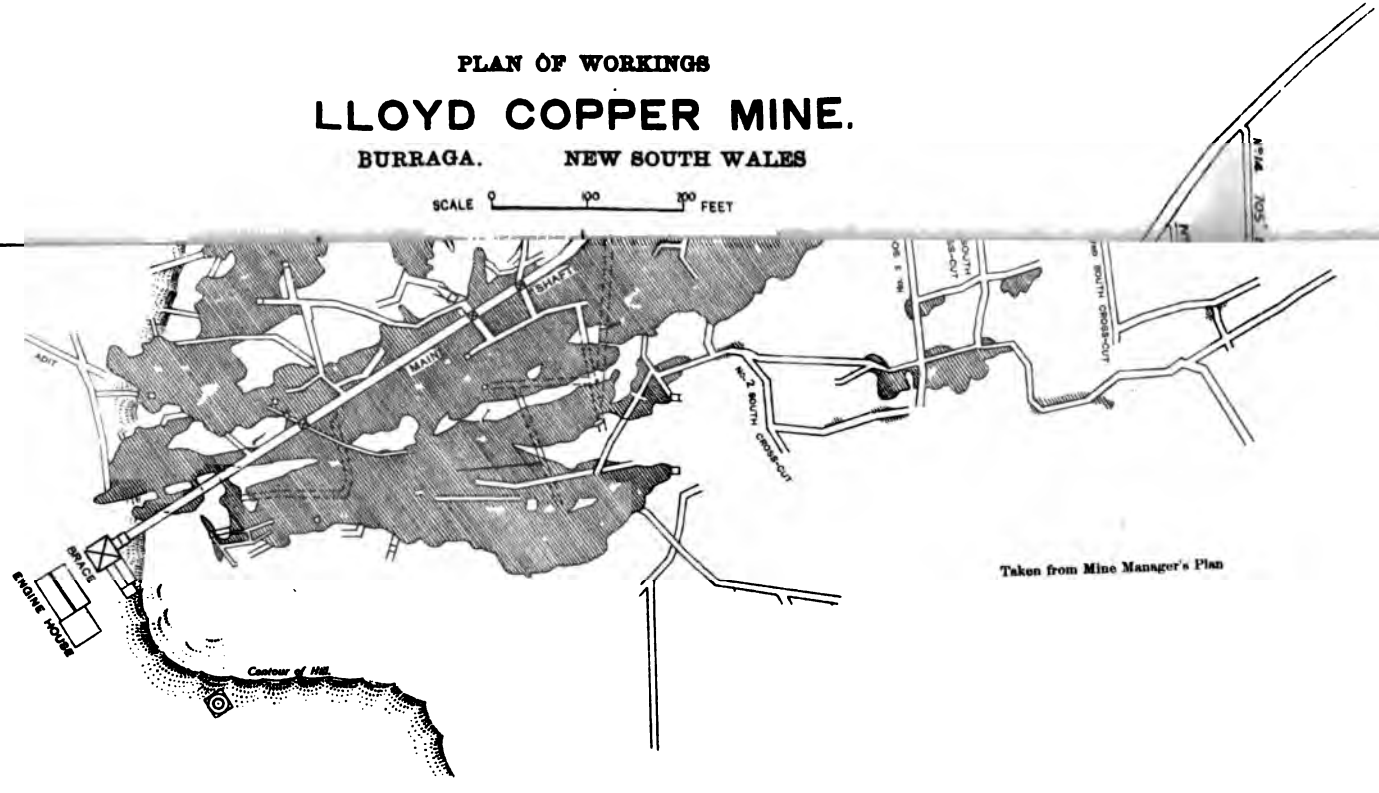
PLAN OF WORKINGS

LLOYD COPPER MINE.

BURRAGA. NEW SOUTH WALES

SCALE 0 100 200 FEET



Taken from Mine Manager's Plan

PHOTO LITHOGRAPHED BY W. A. GULLICK, GOVERNMENT PRINTER, SYDNEY, N.S.W.

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The faulting is probably an expression of the relief of the dynamic movement which broadly folded the strata enclosing the lode.

The Burraga lode has been faulted extensively into a series of step-like planes, as shown on the accompanying plan and section kindly supplied by Mr. W. H. Corbould. From the nature of the early workings, it is apparent that down throws on a minor scale occurred affording a clue to the nature of the more serious displacement encountered in the eastern extension of the later developments, which for a time baffled progress. To quote Mr. Corbould's report to the Lloyd Company, dated 30th July, 1907: "East from the places mined in the past, in the early part of the year a fault was found to displace the lode to a distance of nearly 300 feet. When the lode was again located and further exploited, it was found that eight subsidiary faults had displaced the lode, although to a lesser degree than the main fault. Still these displacements so disturbed some of the ore lenses as to render them almost unpayable, and made the working of the mine more expensive." Locating the ore east of the faults, and ventilating the cross-cuts, entailed 4,760 feet of driving, sinking, and rising.

After the nature of the disturbance, and the direction and amount of throw had been determined in the first or main east fault, succeeding ones were met with confidence and systematic attack. The strike of the faults being more or less meridional and coincident with the dip of the lode, and their throws eastward; it was necessary to turn almost due south at the intersections to pick up the lode on a level course. In every case the eastern extension of the lode has been determined in the manner described, as will be seen by the south cross-cuts on the accompanying plan of the workings. The main east fault being defined approximately by the eastern boundary of the main stoping (shaded area).

In regard to major and minor faulting Mr. Corbould writes: "With respect to faults it has generally been proved that wherever large displacement has taken place in a particular area, a second big displacement seldom occurs, but that several subsidiary faults may be looked for in that vicinity. Such being the case we can hope that as we get further eastward from the main fault, the country will become more settled, as we have close on 2,600 feet to go eastward to our boundary, there is ample room for long lenses of payable ore to be yet located." (Under date of March, 1908, he informed the Writer that developments in that direction were improving.)

Location of the lode eastward of the main east fault directs attention to the western which appears to cut off the lode in that direction. It is highly probable that the lode exists at a higher level west of the fault which threw its eastern extension down to the main working plane. In this case it will be necessary to drive north to intersect it on the dip. From No. 7 West Drive a level in this direction has been started.

The existence of the lode west of the west fault, however, depends upon the amount of displacement; if it exceeds the amount of cover—about 400 feet above the No. 7 level—then of course the quest is hopeless until deeper levels are reached. It is very probable that the outcrop north of the furnaces will yet prove to be the western continuation of the lode.

In this outcrop an underlay shaft has been carried down 142 feet in a reported strong lode, parts of which show good grade copper ore, further progress was abandonded in favour of the western cross-cut from No. 7 level in the main shaft.

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The faults strike, at the different levels, from N. 24 degrees E. to N. 3 degrees W., but mostly to the east of north. The dips vary from 40 degrees to 85 degrees, and are all eastward.

The main west fault, which bounds the lode in that direction, strikes N. 6 degrees E. and dips east at 50 degrees.

The fault planes, particularly the main east and west, afford instructive evidence of the force and direction of the sliding movement accompanying the dislocation. As Mr. Corbould reports: "There is in some instances a distinct drag of the ore on the line of fault." Where such occurs, resistance of fragments of the harder silicious lodestuff has developed smooth lens-like kernels in the soft "dig" resulting from shearing of the country along the line of rupture. At one level the metallic face of the fractured lode was striated and polished, or "slickensided."

The extent of the dislocation may probably be gauged by the width of the crushed material in the fault plane.

A sample of the rock 15 feet west of the main west fault at No. 7 level was petrologically examined by Mr. G. W. Card, who determined it as crushed quartz porphyry. This rock is seen outcropping on the west. East of the fault the rock proved to be talcose schist.

Below the lode on the track from the mill a fragmental rock was regarded as quartz-felspar-porphyry tuff.

A typical quartz porphyry outcrops at the Assay Office.

Process of milling and concentration.

The crude ore, averaging about 3·5 per cent. of copper, is tipped from the shaft into a shoot terminating in an ore bin, from the latter it falls into trucks which are hoisted by cable tram-line to the concentrating mill.

(a) From the ore hopper, into which the crude is tipped, the ore is fed into two Jaques' stone-breakers, where it is reduced to 2½-inch gauge. As it passes the feeders to the breakers, the lumps of first grade ore are thrown out by boys tending the feed.

(b) From the breakers it passes through percussion launders with a stream of water into two similar breakers, which reduce it to 1 to 1½-inch mesh. From the feed launders the "firsts" are picked for direct smelting.

(c) The broken ore then passes to two Cornish rolls running at twenty-five revolutions per minute, and is further reduced to ¼-inch gauge.

(d) From the rolls it passes to trommel screens; the over-sized being elevated by bucket-lifts back to same rolls.

(e) The fine material passing the ¼-inch mesh is led into sixteen-hole (to the inch) trommels. The over-sized passes to May Bros. jigs, working at 170 pulsations per minute; the fines to Handcock jigs.

All crushed materials, save the May jig crudes, pass through the Handcock.

(f) Tailings from May jigs, and "middlings" from the Handcock, are re-crushed in Cornish rolls, running seventy-two revolutions per minute. The over-sized, through a ten-hole trommel, is elevated to same rolls, and returned. The fines pass back to Handcock jigs.

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Concentrating Mill, Lloyd Copper Mine, Burraga.

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The Roaster Plant, Lloyd Copper Mine, Burraga.

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(g) Tailings from Handcock jigs are elevated and passed through a sixteen-hole trommel. The over-sized is carried to a small May jig, working at 240 pulsations per minute. The dredgy material from this jig being carried back to fine rolls, and the tailings to dump.

The fines, passing the sixteen-hole trommel, pass through spitzkastens, to be classified for Wilfley and Phœnix-Weir tables. The spitzkastens are divided into six compartments, with spigots.

(h) The coarsest material from the first two spigots of the first spitzkasten passes to Wilfley tables. From the next three on to one Wilfley, and one Phœnix-Weir. The last spigot material, and that from the last two spigots of second spitzkasten, pass on to one Phœnix-Weir table.

The first three spigots of second classifier lead to two Phœnix-Weir tables, and the remaining (or fourth) spigot to a Frue vanner.

(i) Middlings from all tables are re-elevated to classifiers, and repeated on to first and second Wilfley's.

(j) Tailings from all tables and jigs are carried to an agitating classifier, and the fines therefrom pass into a spitzkasten; the coarser material being treated on Phœnix-Weir tables, and the fines on Frue vanners.

The concentrating plant working two shifts, as at present, treats about 168 tons, or at the rate of 224 tons per twenty-four hours.

The loss in the tailings varies from ·9 to 1 per cent.

The water supply is continuously circulated from the spitzkasten levels up.

The average composition of the Burraga ore as mined, and of the milled concentrates therefrom, is shown in the following analyses by the Company's analyst, Mr. E. G. Ritchie:—

	Ore.	*Concentrates.*
Silica	64·0	34·00
Iron	7·6	23·60
Alumina	11·0	9·60
Lime	2·0	1·20
Magnesia	3·6	trace
Sulphur	6·6	18·00
Copper	3·7	13·30

Calcining and Reducing Plant.

The picked "first" grade ore is roasted in stalls of 25 tons capacity, blinded with Frue vanner fines; four days completing the process.

The mill concentrates are fed damp into three Edwards' roasters, of a capacity of 14 to 16 tons each per twenty-four hours. Six hours are occupied in passage from entry to outlet, when the sulphur has been reduced to the desired proportion of about 8 per cent.

The concentrates are charged hot into the reducing furnaces by means of canister trucks running on overhead tramlines to permanent hoppers above each charging hole, five in the large furnace, three in the small, the hoppers having a capacity of about 3 tons each.

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BATHURST MINING DISTRICT—*continued.*

The smelting plant consists of :—

2 reverberatory furnaces, 32 x 13—capacity, 30 tons per day.
1 „ furnace, 52 x 13 „ 45 to 50 tons per day.

The actual capacity varies with the character of the ore. In charging, the roasted lump ore and concentrates are mixed. In the process of smelting, the large furnace is kept constantly reducing, and one of the smaller blistering, the other helping both operations at intervals.

The reducing furnaces receive three 12½-ton charges per twenty-four hours —sometimes varied to twenty-five hours in the smaller furnaces. With 8-ton charges, about seven in forty-eight hours.

An average grade of 50 per cent. matte is produced in the first operation, and is tapped into ordinary slag pots, which ensures a cleaner product and saves labour in handling as compared with the customary sand moulds. The slag is also tapped over a small settling pot into large double pots carried on trucks on tram rails, and is removed to the dump by horse traction.

The ore is self-fluxing, but difficulty is experienced when the silica runs high, as shown in the following analysis of the slag by Mr. Ritchie :—

Silica (SiO_2)	49·00
Ferrous oxide (FeO)	33·00
Alumina (Al_2O_3)	12·80
Lime (CaO)	2·80
Magnesia (MgO)	·70
Sulphur (S)	·40
Copper (Cu)	·70
	99·40

If the proposed tram-line for ensuring constant wood-fuel supply be constructed, as proposed, it may also bring the necessary limestone flux within economic reach when the ore runs high in silica.

Smelting is continually faced with shortage of fuel, owing to ever increasing distance of team cartage. The daily consumption at the Lloyd Mine and Works, ranging from 125 to 200 tons is sufficient, to prevent accumulation, *pari passu*, with current requirements. Hence when droughts, strikes, or inclement weather supervene, the furnaces have to be closed down.

The 52-feet furnace is a practical result of the fuel problem, ensuring greater smelting capacity with reduced fuel consumption. This—the largest wood furnace in Australia—reduces 45 to 50 tons of ore on a consumption of about 30 tons of wood, against 30 tons on a 25-ton consumption for the 32-feet furnaces.

A noticeable feature of the Burraga furnaces is the perfect maintenance of symmetry, no bulging or distortion being visible. This desirable result is attributed by the management to secure foundations and thorough underbracing.

Fire Brick, Ordinary Brick, and Fettling Clay.

Utilisation of local clays and ground quartz for manufacture of all classes of bricks effects a considerable saving.

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Smelting Works, Lloyd Copper Mine, Burraga.

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BATHURST MINING DISTRICT—*continued.*

Partial analysis by H. B. Gurney reveals the composition of the principal clay.

No. 08–906.—Moisture at 100° C.	·57
Moisture above 100° C.	1·70
Silica (SiO_2)	89·60
Alumina (Al_2O_3)	2·61
Ferric Oxide (Fe_2O_3)	1·70
Ferrous Oxide (FeO)	·36
Lime (CaO)	1·05
Magnesia (MgO)	·72
Potash (K_2O)	·47
Soda (Na_2O)	·35
Titanic dioxide (TiO_2)	·95
Phosphoric anhydride (P_2O_5)	·05
	100·13

A mixture of this clay with a small proportion of a more binding underclay is used for manufacture of bricks for all purposes in kilns and furnaces. For the hotter parts of the latter, 50 per cent. of crushed quartz is added to the clay.

SUMMARY of Output from Burraga Mine.

	Tons of Ore.	Tons of Copper produced.	Value.	Remarks.
			£	
1880	120	.....	.....	43½ per cent. of copper.
1881	2,500	250	16,000	
1882	4,450	465	32,550	
1883	6,150	520	36,400	
1884	.....	582	40,740	Estimated value.
1885	4,215	440	22,500	
1886	.....	281	14,000	
1887	.....	120	7,500	Three months' work.
1888	.....	499	36,000	
1889	.....	.....	.....	No returns. Mine closed for several months.
1890	.....	420	24,150	
1891	.....	.....	.....	No returns.
1892	800	80	3,600	Part only smelted.
1893	.....	.....	.....	Restarted.
1894	.....	622	24,880	
1895	3,311	331	14,895	
1896	.....	424	19,928	
1897	8,907	.....	34,896	
1898	8,518 (5,678 firsts smelted).	570	28,500	2,840 tons of seconds, estimated to contain 142 tons of copper; 150 men employed.
1899	10,256	552	36,400	
1900	9,083	667	48,690	
1901	21,508	1,059	64,599	
1902	29,442	1,131	56,500	
1903	65,397	1,852	100,375	Including 8,411 tons from surface dumps.
1904	30,338	802	44,110	Including 4,546 tons from surface dumps.
1905	60,916	1,207	82,076	Including surface material.
1906	60,000	1,223	100,000	
1907	48,000	1,154	98,000	
1908	18,150	536	30,000	To closing down in May, 1908.
	389,221	15,812	£1,020,825	

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The Burraga Mine occurs in a belt of highly-altered rocks shading from porphyry into schist and slate? Samples selected by the Writer have been microscopically examined by Mr. Card, A.R.S.M., Curator and Mineralogist, and the following determinations arrived at :—"No. 3,308, a fine-grained rock with gneissose structure. It consists of quartz, plagioclase, calcite, and biotite, with iron ores. It has a fragmentary appearance, but is in all probability an acidic igneous rock altered by pressure. No. 3,307 is much finer grained and highly altered. It appears to represent a more highly-altered form of 3,308."

Burraga District.—About 1 mile south of the Burraga Mine the Mining Exploration and Development Company prospected private land. A lode channel from 3 to 4 feet wide was opened, having a N. and S. strike, and dipping E. at 50°. The lodestuff consisted of quartz, with copper and iron sulphides and a little zinc blende in crushed country. A sample, $\frac{1\,3\,0\,2}{5\,8}$, yielded—copper, 8 per cent; zinc, 16 per cent.; and silver, 2½ oz. per ton.

A short distance west, in the bed of a small creek, a very kindly-looking gossan is exposed for a considerable width. Traces of copper carbonate are visible in freshly-broken fragments. An assay, $\frac{1\,3\,0\,2}{5\,8}$, yielded but a trace of copper—0·1 per cent.—and under 2 dwt. of gold per ton. It has all the appearance of a thoroughly leached cap of a pyritous lode; but subsequent test by shaft failed to discover any workable ore.

Inspector Polkinghorne reported (P.B. $\frac{1\,3\,2\,7}{5\,8}$) slate with small veins of copper ore in joints, on Thompson's Creek, about 1½ miles north of Lloyd Copper Mine.

Aided to sink to 100 feet. Last 10 feet of sinking in curly slate, with splashes of copper sulphide. No further record.

McKinney, Hall, and party sank to a depth of 160 feet to the south of Lloyd Mine; nothing of value disclosed.

Bowie and party, on Thompson's Creek, 2 miles south of Burraga, sank and drove 100 feet; traces of copper only.

Eleven miles east from Burraga, adjoining Isabella Public School ground. Parish, Isabella; county, Georgiana.

Inspector Milne reported (P.B. $\frac{2\,6\,6\,5}{0\,7}$) a well-defined channel in schist, about 18 inches wide, with bunches of gossan containing splashes of yellow copper ore.

Aided to sink from 13 to 63 feet.

At a later date pyrites, with a little copper sulphide, was reported in bottom of shaft. Vein underlying slightly to the west; water making.

The Burraga Copper Company, Ltd., which took over Stain, Cassell, and party's copper lease, 1 mile east of the Lloyd Mine, continued prospecting during 1900, the underlay shaft being continued to 255 feet. A main vertical shaft was then started, which was expected to cut the lode at 300 feet.[1]

The vertical shaft was down 200 feet in 1901, and was driven 60 feet in a large lode carrying a little copper ore.[2]

Orange Division.

Byng.—In addition to the Carangera, Ophir, and other copper mines near Byng, which receive independent notice, copper ores occur on Mr. W. Hawke's property, about 12 miles S.E. of Orange. The lode was discovered several years ago during fencing operations. It strikes N.E. and S.W., and dips

[1] Ann. Rept. Dept. Mines for 1900, p. 55. [2] *Ibid.* 1901, p. 54.

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Lloyd Company's Reservoir, Burraga.

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Cadia Copper Mine and Iron Duke Hill.

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S. easterly. The outcrop is from 1 foot to 1 ft. 6 in. in thickness; at 8 feet it increased to 2 feet; below this it appears to pinch. The ores consist of carbonate and black oxide, which have not yet been tested. (*See* Hawk's Nest and Ratscastle.)

On Mr. Webb's property, near Byng, a copper lode occurs, from which the following parcels of ore were treated at the English and Australian Smelting Co.'s Works, Waratah:—

6	tons	16	cwt.	yield 19½	per cent. copper.
7	,,	1	,,	16¾ ,,	,,
3	,,	2	,,	12 ,,	,,

On the Springfield Estate, Byng, H. B. Thomas sank 90 feet and drove 60 feet. Ten tons of ore raised, stated to assay 10 per cent. copper and 5 dwt. gold per ton. (Ann. Rept., 1906, p. 46.)

Cadia Copper Mine (Old).—The earliest official record of this mine is that contained in the Official Catalogue of the Sydney Exhibition of 1870; on page 443, the Cadiangulong Copper Company was reported to have extensive works above and below ground, including a complete range of furnaces. The mine is situated close to Cadiangulong Creek, 15 miles south of Orange, and is owned by the Scottish Australian Investment Company, from whom particulars of past operations are not obtainable. In 1881 the late Government Geologist—Mr. C. S. Wilkinson—reported the Cadia lode to be 6 feet in thickness, and the ore chiefly yellow sulphide associated with quartz. It dips N.N.W. at 75°. He also mentioned that about half a mile N.E. from this lode a large cupreous ironstone or gossan lode crosses the main creek. [The Iron Duke.] It has a thickness of over 70 feet, and strikes N. 20° W. So far as tested the lode was not rich enough to work for copper, but Mr. Wilkinson was of opinion that when sunk upon to water-level, where the sulphides would be found undecomposed, good ore would be met with.

In 1882, 48¼ tons of ore were obtained at Cadia, and a little tributing was done in 1883.

Several lodes occur on the property, the principal ones being the Cadia and Iron Duke. The main shaft of the Cadia reached a depth of about 232 feet; 120 feet vertical, 60 on the underlay, and 40 feet in a winze. The lode was about 12 feet wide, with good ore at surface, and about 5 feet at bottom, but low grade and dredgy, with abundant iron pyrites. The main stope was about 50 feet long. Work has not been carried on for thirty or thirty-five years in this shaft. A substantial stone engine and pumping-house was erected. The water, raised by a beam engine, was used for concentrating purposes; the remains of a set of jigs are still to be seen. The smelting furnaces were erected on Cadiangulong Creek, a short distance from the mine.

The Iron Duke lode in 1898 had been opened by tunnel and shaft. The former, 1,300 feet long, according to the Manager of the Scottish Australian Mining Company (which owns the property) starting from the west bank of the creek, passed through the ironstone lode, in which a little copper ore was visible in places. For a considerable distance after passing the ironstone the tunnel pierced, in a most erratic, winding manner, solid andesitic country destitute of any trace of lode formation.

Two cross-cuts had been driven from the tunnel in the ironstone lode, and a considerable amount of stoping done, following a vein of good carbonate ore. About 2,500 tons of ore, averaging about 16 per cent., are reported to have been extracted under the direction of the late Captain Holman.

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Where the creek cuts across the lode a rich vein of carbonate and red oxide, 3 to 4 feet wide, was discovered about twenty years previously, about 40 tons being extracted. A shaft was started about 1897, close to the bank of the creek, to continue opening this find, but was stopped owing to litigation.

On the opposite side of the creek from the tunnel a large face of gossan is exposed, through which traces of copper carbonates are visible. A shaft was sunk at this point. A little ore from it can still be seen at surface, consisting of sulphides of iron and copper.

The latest previous smelting at this site was about 1888, when some 4,000 to 5,000 tons are reported to have been treated.

The tunnel had recently been cleaned out, and was in excellent condition when examined in 1898, but the greater part of its length appeared entirely off the course of the lode, The tunnel-level was too shallow for effective test of the lode; greater depth being required than that attained in winzes—about 40 feet—below the tunnel.

Certainly the shaft on the opposite bank of the creek pierced the sulphide zone, but it is doubtful whether drives, if any, from that level penetrated into the hill to the west. The frequent barrenness of ironstone caps of copper lodes, due to the unstability of copper salts in the presence of leaching solutions, encourages the belief that more concentrated bodies of the ores of that metal may be found below the oxidised capping in this instance. Certainly efforts should not be relinquished until the sulphuret zone has been explored under the main outcrop.

The abundant ironstone of the Iron Duke cap would be of excellent service in fluxing the sulphides from a depth, if such exist in payable quantities; failing this, as a suitable flux for public smelting works it will have a value in the future. The small percentage of copper carbonates disseminated through it may debar its use for iron smelting because of the deleterious effects of copper on iron, rendering it "red-short," or brittle at a red heat.

Whilst writing of Cadia, it is desirable to refer to a report by the first Government Geological Surveyor—S. Stutchbury—in July, 1851, in which he alludes to the existence of strong evidence of copper lodes in the neighbourhood. The following extract contains the reference:—"In a gully or creek called the Waterfall, running into the Cadiangulong or Oaky Creek, at the western end of a section of 640 acres, forming Lot 1, for sale May 7th at Carcoar, and at the extremity of a mountain spur known as the Rocky Range [Canoblas? these creeks rise in the Canoblas.—J.E.C.], there is an immense mass of oxydulous iron, forming in one solid mass a precipitous waterfall of about 60 feet in height. In this mass of iron, especially in the joints, there is brilliant crystallised iron pyrites, with a small quantity of yellow copper ore, and traces of blue and green carbonates of copper. A few yards below the waterfall large masses of yellow ochreous iron 'gossan' occur in the banks and bed of the creek. This gossan contains a considerable quantity of earthy green carbonate of copper, also plush-like malachite. Upon sinking a short distance into it on the eastern side, a rich lode of grey sulphuret of copper was found. In traversing the creek southwards numerous indications of other lodes were visible, together with large masses of mundic." (*See* "Cadia Extended.")

Cadia Copper Mine (*New*).—Portions 83, 86, 87, 27, 29, 30, parish Clarendon, county Bathurst. About 12 miles south-westerly from Spring Hill

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Block of Iron Ore—Iron Duke Outcrop—with Canoblas in Background.

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Railway Station, and 14½ miles from Orange. Worked under tribute to the Scottish-Australian Mining Company by the Cadia Mining and Smelting Company since June, 1905.

The principal scene of operations is the copper deposit associated with the Iron Duke iron lode, which has been brought into prominence as the most extensive deposit of iron-ore yet discovered in the State.[1]

The East and West Cadia lodes near by are also being worked by the syndicate on a lesser scale for fluxing purposes.

The Cadia or Iron Duke copper lode had already been extensively opened, in February, 1908, when again visited by the Writer, as will be seen in the accompanying plan and section.

The copper ore occurs as a flat sheet immediately under the iron oxide bed. The massive, flat, sheet-like outcrop of the latter passes downwards into a mixture of specular iron and pyrite, with a little chalcopyrite and partially-altered andesite, affording evidence of derivation from andesite, as suggested by Mr. Jaquet (*ibid.*), with seggregation of the iron, and leaching and redeposition of the copper below the iron cap. The anhydrous form of the iron oxide is unlike surface oxidation.

Below the latter the enriched copper zone forms a thick bed of gossany ore with oxide of copper and native copper; the latter in places being heavily charged through the loose black oxide. The iron ore will have no value for iron smelting below the seggregated mass forming the superficial cap, unless leached to remove the copper, and roasted to eliminate the sulphur of the pyrite.

The copper lode dips eastward at an angle closely corresponding to the slope of Iron Duke Hill, but the dip is reversed near the creek. This reversal, and the probable identity of the same bed in the Cadia Extended, indicates wavy folding of the original andesite sheet from which the metalliferous deposits probably originated.

The cupriferous oxidised portion in the Iron Duke mine has a thickness of from 10 to 50 feet in places. Denudation, and the eastern rise of the mass at the creek, brings the lode now worked above the water level; hence, sulphide resources can hardly be anticipated in following it. Interest, therefore, centres in the developments *below* the main ore body, which have as yet only been attempted from the deepest, or No. 1 shaft, on the creek bank. A drive 212 feet west from the bottom of this shaft pierces a low grade mass of specular iron, pyrite, and partially-altered andesite, with a little copper sulphide. An average sample, chipped from the first 56 feet from the shaft, is stated to have returned 2·6 per cent. of copper. It is doubtful whether mechanical separation is possible; hence, the amenability of this ore to blast furnace treatment is the problem to be solved.

Below the main ore-body the main shaft has been sunk 23 feet in a whitish, clayey deposit without change, but there are indications of the low grade body in the No. 1 shaft being at a lower level still. The oxidised copper bed rests, throughout the extensive blocking out drives and cross-cuts, on a similar whitish, clayey floor.

It is very desirable that the main shaft should be continued below the known ore bed in search of others that may exist.

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[1] *Vide* J. B. Jaquet, Mem. Geol. Surv. N. S. Wales, No. 2, 1901, pp. 27–30.

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The copper bed has been proved by several shafts for a width of about 200 feet, and has been followed on its rising western longitudinal extension under Iron Duke Hill for 780 feet from Cadiangulong Creek, which partially intersects it.

The main shaft is the most western in the hill, it cut the copper zone at a depth of 64 feet, immediately below the iron cap. The copper lode has here a thickness of 22 feet 6 inches, and, as already indicated, an eastern dip. Whether it persists to the rise under the whole of the iron cap, or whether the leaching solutions followed the inclination of the bedding until sufficient cover or depth was reached, remains to be proved by a continuous western level. Certain it is that at no great distance below the summit of the hill, and a long way west of the workings, copper carbonates have been exposed to a small extent in the solid iron cap, the results of a bulk assay test of which by the Syndicate's analyst, D. C. Winterbottom gave :—

Copper	4·1
Iron	57·0
Alumina	4·0
Silica	5·8

A further sample taken by the Writer, gave the following :—

No. 08–580—Copper	4·70	
Gold, a trace		per ton.
Silver, 8 dwt. 17 grs.		

In the 120-feet level from the main or No. 6 shaft, the lode includes a large mass of specular iron and pyrites, with occasional bunches of chalcopyrite, the lode here having a thickness of 17 feet 6 inches to 22 feet 6 inches.

From the 67-feet level in No. 5 shaft a winze was being sunk, at the corner of south and south-west drives, in rich black oxide heavily charged with more or less granular metallic copper worth from 30 to 40 per cent. The lode in this level runs up to 50 feet in thickness.

In the outcrop on the east bank of Cadiangulong Creek, opposite No. 1 shaft, a shaft was sunk and a tunnel driven east, during earlier workings. Traces of copper carbonates are visible in the bluff face entered by the tunnel. Particulars of these provings are not available, but fragments of mixed sulphides are still at grass.

Further east—up the slope of the ridge—is the section known as East Cadia, with Chilcott's shaft, now being worked by the Cadia Syndicate for sulphide flux. The latter was cut at a depth of 72 ft. At 100 ft. a lens was opened for a length of 90 ft., and a width of 12 ft., containing sulphide of copper, in part bornite, the average copper value being about 4 to 5 per cent. The boundaries are not well defined owing to absence of walls or any marked division between ore and country.

The West Cadia lode is distinct from the Iron Duke, and close to the original Cadia lode, opened about 1862.

It strikes about N. 70° E., and was extensively opened by seven shafts and a tunnel, the latter extending for over 1,000 feet, in the earlier days of copper mining in this locality. Apparently the tunnel level is the lowest

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vertical proving. The Cadia syndicate is cleaning out the latter and stoping up in places for sulphide fluxing ore, which is improved by association of limestone, having the following composition:—

No. 08-582—Calcium carbonate ($CaCO_3$)	96·78
Ferric oxide and alumina ($Fe_2O_3 + Al_2O_3$)	1·16
Gangue	1·48
Magnesium carbonate and undetermined	·58
	100·000

The copper ore is erratic in mode of occurrence, and not persistent in the channel. Bunches of good ore occur in places, but die out in the andesite country. Walls, or dig, or any marked lines of division between ore and country are absent. The limestone, as calcite, occurs in parts in irregular bands and lenses.

Judging by the plan of early operations a good deal of stoping, in the aggregate, has been done above the tunnel level, from shafts and intermediate levels, chiefly in isolated blocks or lenses. The greatest amount of backs above the tunnel level being 240 feet in the west, or Rodd's shaft, but stoping in the latter does not appear, by the plan, to have been carried below 90 feet from surface. The principal stopes lie between Gundy's and Johnson's shafts. The average value of the ore at present being mined in this section is 4 to 5 per cent.

The composition of the Cadia ores, sold, and smelted locally, is well shown in the following analyses by Mr. D. C. Winterbottom:—

Lode.	Ore.	Copper.	Iron.	Alumina.	Insoluble.	Sulphur.	Lime.	Remarks.
		%	%	%	%	%	%	
Iron Duke.....	Oxidised—"Firsts"*	12·8	32·1	9·4	23·0	6·0	..	Four weekly tests.
,, ...	,, "Seconds"	6·8	31·2	11·0	30·0	6·0	—	.....
,, ...	Sulphides from 56 feet, along west drive, No. 1 shaft.....	2·6	35·0	10·4	24·0†	6·0	..	†Silica.
,, ...	Specular iron and pyrites, west drive, No. 6 shaft, 70-feet level	2·1	44·6	8·0	17·5†	6·1	..	† ,,
Chilcott shaft—East Cadia.	Sulphide—one sample	6·3	24·0	6·5	39·0	..	5·0	.....
West Cadia	From winze below adit	5·7	7·0	7·0	50·0†	..	8·0	†Silica.
East and West Cadia.	Average of three weekly samples at furnace	4·2	19·5	9·2	52·0	8·0	..	.....
South Flux shaft	Specular iron and pyrites (Flux).	Nil	20·0	..	36·0	22·6	11·2	.....
	Slag from reverberatories—average of three weekly analyses	·0	44·2‡	15·4	37·6	..	1·4	‡FeO.

* Average assay of all "firsts" sold to smelters for twelve months ending 25th January, 1908, was 13·3 per cent. (wet assay) of copper.

The value of the Iron Duke oxidised ores taken, by Mr. F. Danvers Power, from twenty-eight different faces in the workings ranged from 1·0 to 14·8 per cent. copper, and averaged 6·8 per cent.

The total output from June, 1905, to the end of 1907, amounted to 5,662 tons, the copper contents of which totalled 1,009 tons 17 cwt. 3 qrs. 16 lb., equal to 5·6 per cent.

Of the above amount part was marketed in the form of matte, ranging from 41·6 to 72·8 per cent in copper contents.

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BATHURST MINING DISTRICT—*continued.*

The Syndicate estimates that there were 3,968 tons of thirds at grass at the end of the year, of an assay value of 4 per cent copper.

During the period mentioned upwards of 3,300 feet of sinking, rising, driving, &c., were carried out in provings and blocking out.

Smelting plant.—The smelting plant consists of—

2 Reverberatory furnaces, 18 ft. x 11 ft., inside measurement		Capacity, about 62 tons ore per week.
1 ,, ,, 21 ft. 6 in. x 11 ft.,	,, ,,	
1 ,, ,, 22 ft. x 11 ft.	,, ,,	

Smelting charge.—Small furnaces { 8 cwt. sulphides ores, 32 cwt. oxidised ores } Matte, 50 per cent. copper, produced in one operation.

,, Larger ,, { 10 cwt. sulphides ores, 40 cwt. oxidised ores } Matte, 50 per cent. copper, produced in one operation.

Firebricks obtained from Lithgow, and from Bathurst (Dewar's). Local red brick made on the estate.

Clay from Reserve 70A, parish Clarendon, county Bathurst, close by, used for lining and plugging.

About 200 men are employed at Cadia, including wood-cutters and carters.

The Syndicate dispatches first-grade ore to Newcastle, averaging from 14 to 16 per cent. copper; the seconds being smelted locally.

Carriage by team to Orange costs 12s. 6d. per ton; rail thence to Newcastle costs 11s. 10d. per ton; total, 23s. 10d. per ton.

Construction of a branch railway from the nearest point of the Great Western—an estimated distance of about 12 miles—would greatly advance the interests of the district, both mining and agricultural.

If the iron smelting industry at Lithgow prospers, as is devoutly to be wished, tapping the iron ore resources of Cadia will become a necessity. With such an accomplishment, the financial aspect of the railway can be confidently faced.

The clay used for fettling is obtained from Reserve 70A, parish Clarendon, county Bathurst, about 3 miles from the mine. Its composition is shown in the following analysis by Mr. H. P. White:—

No. 08–511—Moisture at 110° C	3·38
Water above 110° C	4·48
Silica (SiO_2)	73·52
[1]Alumina (Al_2O_3)	9·75
Ferric oxide (Fe_2O_3)	4·55
Ferrous oxide (FeO)	·36
Magnesia (MgO)	·58
Lime (CaO)	·52
Potash (K_2O)	·79
Soda (Na_2O)	·65
Titanic dioxide (TiO_2)	1·10
Organic matter	·16
	99·84

Cadia Extended Copper Mine (formerly Canoblas) portions 28, 37, and 38, parish Waldegrave, county Bathurst, about 2¼ miles from Cadia Mine.

Occurs in andesite, and after same manner as the Iron Duke lode—probably forming part of the same extensive sheet.

In the bed of a small creek, which dissects the mass for perhaps a hundred feet, a large mass of oxide and sulphide of iron with a little copper pyrites, forms the waterfall described by Stutchbury in 1851 (p. 128.).

[1] Including a very small amount of phosphoric anhydride (P_2O_5).

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View of Cadia Smelting Works and Village.

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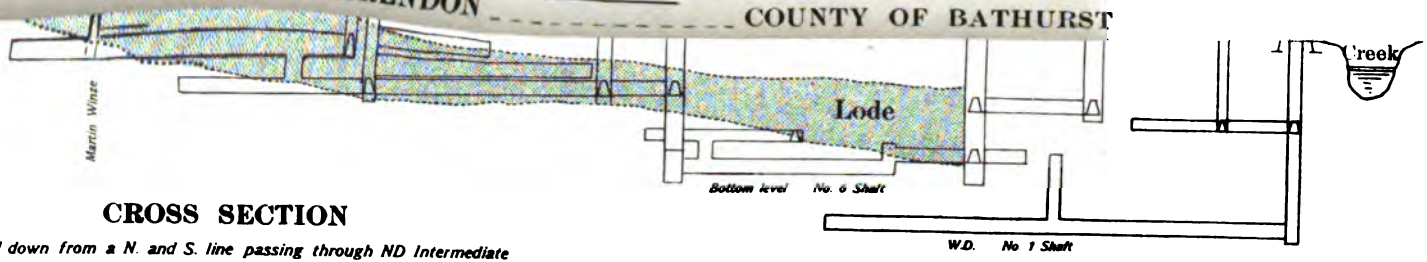
CADIA COPPER MINE

Iron Duke Workings

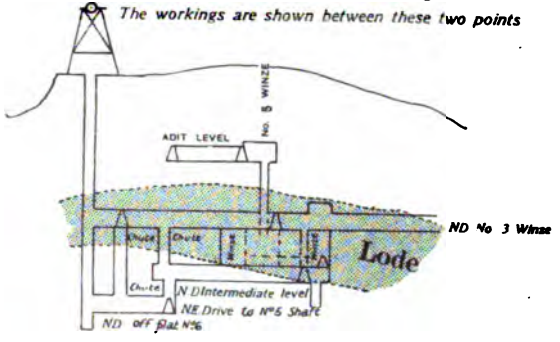
PARISH OF CLARENDON ---------- COUNTY OF BATHURST



CROSS SECTION

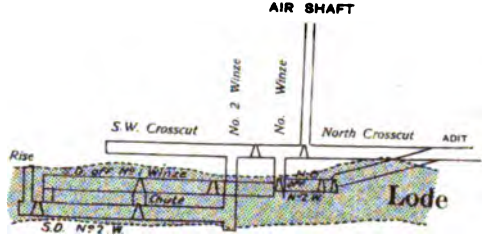
Projected down from a N. and S. line passing through ND Intermediate Level, No. 6 Shaft, and another N. and S. line through No. 3 W Adit Level

The workings are shown between these two points



CROSS SECTION

Showing workings between Air Shaft and No. 2 W. projected down from N. and S. lines drawn through these two points



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Taken from Mine Manager's Plan

PHOTO-LITHOGRAPHED BY W. A. GULLICK, GOVERNMENT PRINTER, SYDNEY, N.S.W.

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On the east bank of the creek two shafts have been sunk, 40 feet and 80 feet and connected at the former level. In these shafts the ore is mostly pyrite, or a mixture of pyrite, specular iron, and andesite.

From the lodestuff extracted in driving 35 feet east from the 80-foot level, an average sample yielded :—

No. 08-583—Copper	1·30	per cent.
Iron	37·24	,,
Silica	20·75	,,
Sulphur	3·52	,,
Gold	1 dwt. 2 grs.	per ton.
Silver	5 dwt. 10 grs.	,,

From north-west drive at same level :—

No. 08-584—Copper	6·22	per cent.
Iron	21·56	,,
Silica	27·08	,,
Sulphur	14·33	,,
Gold	a trace.	
Silver	1 oz. 6 dwt. 3 grs.	per ton.

Fourteen assays by Mr. D. C. Winterbottom gave an average of about 3 per cent. of copper from what must be regarded as the enriched zone. Deeper tests are necessary to determine the true value of the sulphides.

A 60-ton blast-furnace was in process of erection in January, 1908, by the Cadia Extended Mining and Smelting Company.

A few hundred yards below the Cadia Extended a slightly pyritic mass in sedimentary strata, locally designated the "Sulphide Lode," has been intersected by the same creek. It differs essentially from the andesitic lodes, and is unpromising in its superficial character.

A sample chipped across the face of the bluff, and another selected from the most pyritic portions, gave no reactions for copper, and traces only of gold and silver.

Under the name of *Canoblas Copper Mine*, the Cadia Extended deposit was opened prior to 1859; but beyond a little sulphide ore being extracted occasionally to assist in fluxing the ores of the old Cadia Mine, little work was done.

Mr. S. L. Bensusan states:—"The copper lode was developed to a small extent about 1862, when several parcels of good-quality ores were forwarded to and sold in England. Since that period, some 300 or 400 tons of copper ore have been smelted at Cadia Copper Works, chiefly of low-grade percentage, obtained solely from the adit level extended about 30 fathoms into the eastern hill.

Canoblas.—Copper ores and native copper are associated with rocks of similar composition to those of the Canoblas in the Orange, Carcoar, and Wellington District, and their possible connection was referred to by Geological Surveyors David and Stonier ($\frac{1}{p}\frac{8}{s}\frac{2}{s}\frac{0}{v}$) in the following terms :—

"Near Orange we inspected the Canoblas, the great extinct volcanoes of New South Wales, and found, as we had previously suspected, that the copper-bearing rocks of Waugoola and Walli, alluded to in previous geological reports, are probably lavas which have flowed from the vicinity of the Canoblas, and perhaps had their source in the Canoblas themselves. These lavas, as well as those seen at the 'Old Man Canobla,' are not basalts, but andesites, a variety of volcanic rocks, whose existence in extensive sheets like these has hitherto never been recorded in New South Wales. Copper

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occurs locally, in a metallic state and as green carbonate, in the steam holes of this rock near Walli, and in a vein in the same rock near Wood's Flat at Waugoola."

Carangara (or Carangera) Copper Mine, Byng (formerly known as the Cornish Settlement).—On 12th April, 1851, Mr. S. Stutchbury reported, after an inspection of this property: "The rocks, or 'country,' as the miners term the strata in which the lodes occur, are principally composed of clay-slate, chlorite and talcose schists, with veins of quartz. No elvan has yet been seen; the lodes, large and small, are very numerous. No 'Champion' lode has yet been met with. The 'Master' lodes appear throughout the district to have a direction N. 20° W., with small, bifurcating, diverging, and large branches. The underlay is westerly, at an angle varying from 40° to 62°. At the level of the creek, and 27 feet to the north, they have commenced driving an adit which they find will clear them 18 fathoms from water."

Three shafts had been sunk at that time above the tunnel-level, but no particulars are given. The ores above the 10-fathom level are stated to have been similar to those of the Coombing Park Mine, near Carcoar: below that level sulphides occurred.

In August, 1854, a Select Committee of the Executive Council reported on the Carangara Copper Mining Company's Incorporating Bill, the company having been projected about sixteen months prior to that date—April, 1853. The object of the company, as stated in the Bill, was to work copper lodes in certain lands, and to purchase metallic ores, &c. The extent of the Carangara Estate being three portions of land 320, 156, and 320 acres respectively, in the parishes of Byng and Anson, county Bathurst, formerly the property of Messrs. Lane and Glasson.

Copper ores from the mine were exhibited by the company at the Paris Exhibition of 1855. Mining and smelting were carried on in this locality for a number of years, but no particulars are obtainable of the output.

In the vicinity, and extending to Lewis Ponds, the following mines were opened and worked about this time, and later, viz.:—Britannia, Belmore, Moonta, Nelson, Gurophian, Ophir, Icely, East Block, Mt. Fraser, Algar, and others. Under the title of the Great Western Copper Mining Company, Ltd. (which *see*) most of these mines were floated into a public company in 1872; the first half-yearly report being issued in February, 1873.

In the Mineral Statistics of New South Wales prepared for the Philadelphia Exhibition in 1875, the following particulars are given of the lode worked at that time by the Carangara Company:—

Thickness of lode at	30 feet	=	3 inches	Strike, N. 15° W. Dip, 60° westerly.
"	"	180 "	= 12 "	
"	"	240 "	= 18 "	

5,600 tons of ore raised yielded 784 tons of copper. Method of treatment being heap roasting and reverberatory smelting.

In [1881] p. 131 the late Government Geologist, Mr. C. S. Wilkinson, visited Carangara; the mine was then idle. Mr. Wilkinson described the main shaft as being in a lode striking N. 15° W. through altered serpentinous schists and conglomerates, and dipping W. 20° S. at 53°. Near its southern end a wide quartz reef striking E. 10° N. meets the lode almost at right angles. Five chains higher up the creek is a wide quartz porphyry elvan 20 feet wide, apparently running with the strike of the beds. Two other

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large quartz reefs occurred about half a mile further north. Mr. Wilkinson expressed the belief that the reefs and copper lodes would be found auriferous, which was subsequently proved. In 1886 both gold and silver were found to be present in the copper ores, and operations of late years have been confined to winning these metals. Tributing for gold was carried on in the old mine for five years, but ceased in 1898, owing to the owners' intention to work the mine.

The Gold and Copper Fields Syndicate reopened this mine in 1900. Mr. L. Parker, A.R.S.M., under date March 12th, 1900, stated:—"That from the 'Bull' lode, about 200 feet west of the main lode, the greater part of the ore mined, was taken at one period."

An adit on main lode was driven 1,050 feet, and a vertical shaft sunk 200 feet to the west of the lodes, all previous to 1890.

In 1898 the vertical shaft was repaired and sunk to 214 feet, and a cross-cut put out to meet lodes.

An attempt to smelt Mount Fraser (P.G.L. 14) ore was made by the Springfield Pastoral and Estates Company, which owned and worked the mine, but was not persisted with.

Carcoar Division.

Carcoar District.—In April, 1851, Mr. S. Stutchbury, after describing the Coombing copper lodes, goes on to state that "the ranges south of the Carcoar Creek, east of the Coombing Estate, and west of Mount Lachlan 'Cambulla,' consist of alternating schists and syenite or granitic rock.

"On the two spurs from the little Mount 'Cambulla-narang' [Little Mount Macquarie?—J.E.C.], I have opened several lodes of copper. The first appears to take a course W. 12° N. and E. 12° S. This lode close under the grass carries a thickness of 2 feet, with its underlay to the southward, and much valuable ore, principally tile ore and green carbonate of copper.

"In the creek about 150 yards north the back of another lode appears nearly 6 feet wide; this may be traced direct north over the next range until it reaches the main creek. On the summits of its course it is overlaid by rich crystalline magnetic iron ore.

"There also appear in the escarpment at the north end evidence of two parallel lodes, one on the eastern and one on the western side of the lode before described; these three lodes would not extend beyond 200 yards in lateral distance."

From camp near Curragurae, he wrote further of this district, on the 18th July, 1851: "A few yards above the spring [on Lundy Swamp where Couragee Rivulet takes its rise.—J.E.C.] there are several lodes of 'gossan' carrying iron pyrites. At the mouth of the second gully below, several veins of chloritic, talcose, and quartzose stuff with great abundance of mundic; those I have but little doubt are the backs of lodes of yellow copper. On the west side of the main creek, immediately opposite the second gully below the upper fall, by moving a large body of rock containing pyrites, I discovered a fine vein of yellow sulphuret of copper, accompanied by green carbonate of copper; its width is about 1 foot 6 inches; from appearance it was likely to be joined by two other thin branches or veins of yellow copper.

"At the first waterfall on the Maramar or Flyer's Creek, direct south from the spring heads, in Long Swamp, there is a lode of yellow sulphuret of copper crossing the creek direct east and west from section 1, Church and

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School Lands, into section of land consisting of 443 acres 3 roods 1 perch, for sale at Carcoar, 7th May [1851.—J.E.C.] There is a small lode-crossing in the same direction a few chains further south."

Between Carcoar and the Coombing Park Estate, at the north boundary of the latter, Messrs. Links discovered traces of copper carbonates dipping rather flatly westward in schistose—or crushed—hornblende porphyry. Two shallow shafts were sunk, and a third was being put down to cut the lode at a depth. A sample of copper pyrites from this site yielded $\frac{2}{9}\frac{8}{5}\frac{2}{5}$ copper, 26¾ per cent.

In $\frac{1}{D.}\frac{8}{6}\frac{8}{6}$, a copper lode was discovered whilst making a road from Carcoar to the Cobalt Mine on McKillop's property. The Mining Registrar reported that a shaft was down 25 feet, and ore was being raised for despatch to Newcastle, but evidently the quantity was very limited. A sample yielded $\frac{2}{9}\frac{3}{5}\frac{8}{5}$ copper, 11 per cent. From Stoke's Estate, half a mile east of Carcoar, samples of copper pyrites, $\frac{2}{9}\frac{6}{5}\frac{2}{5}$, and $\frac{2}{9}\frac{1}{5}\frac{2}{5}$, yielded 26 per cent. of copper, and 2 to 3 oz. of silver per ton.

Rockley Division.

Cash-Essington Mine, portion 2, parish Adderley, county Westmoreland, Native Dog Creek, Essington.—The Cash Shaft is a new opening on the southern extension of the old Essington lode in the adjoining portion. Strike N. 20° W., dip S. 70° W. at 30° to 40°.

In 1905 aid was granted to sink the 20-feet shaft to 100 feet, on a lode reported by Inspector D. Milne as 3 feet wide (P.B. $\frac{2}{0}\frac{1}{5}$). Later, on sale of mine to the Lloyd Copper Company, this aid was refunded.

The shaft is 250 feet deep, and driven at the 150-feet level 100 feet north and 80 feet south. No stoping done. The lode averages 2 feet to 2½ feet wide, making in places to 4 feet. At 200-feet level, driven 25 feet on course of lode.

The ore consists in the lower levels of sulphide of good quality, but mixed with quartz and country in part.

During the above development, in 1906 and 1907, 121 tons of ore raised yielded an average of 8·7 per cent. of copper.

The Old Essington Mine is situated on the south bank of Native Dog Creek, a few chains along the northern strike from the Cash Shaft. On the opposite side of the creek is the original North Essington, also on the same lode, where a shaft was sunk 30 feet, and a tunnel driven from the bank for 30 feet.

West of the Cash-Essington lode, three parallel lodes occur in portions 2 and 5, within a distance of about 20 chains. These appear to strike from N. 50° to N. 70° west, and are of silicious character. A fair amount of ore has evidently been extracted from some of them, judging by the dressing heaps.

The Essington lodes occur in a schistose rock of hornblendic character, which alternates with several quartz-felsite dykes; the copper ore is confined to the former.

Definite particulars of early developments in the Essington and Western lodes are not available. The former is stated to have been sunk on for 100 feet, and driven south at that level for 80 feet or more. About 1899 this shaft was unwatered and cleaned out by C. Richardson, who extracted some ore. A tunnel was also driven in from the creek bank in the early days of copper-mining in this locality.

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In connection with the above lodes a reverberatory furnace was erected about 1873 or 1874.

Eastward, on the opposite side of Native Dog Creek, several other adjacent lodes occur, on which are the Fullback, Prosper, Integrity, and Murphy's mines (which see), all occurring in the hornblendic schist, in close proximity to quartz-felsite.

It would appear, from the number and nature of the copper lodes in this locality, that there is room for the operation of a company controlling the whole, with a central smelting plant on the permanent creek, where an adequate water supply could be conserved.

The direct smelting ore from a coarse breaker could be picked by hand, and the balance submitted to concentration; in which the predominant quartz gangue would insure good milling results.

Carcoar Division.

Coombing Park Copper Mine, about 2 miles S.W. of Carcoar.—After the failure of the Belubula Copper Mine (opened in 1845), the mining captain, Mr. Reed, proceeded to open the Coombing Park lode for the late Mr. T. Icely, the date being probably prior to 1850, for in April, 1851, the first Geological Surveyor—Mr. S. Stutchbury—reported that the lode had been opened to some extent. The report is valuable as the only one extant on this property. Of the mine Mr. Stutchbury wrote:—

"Its geological position is upon an 'elvan' course in greenstone slate with occasional bands of clay-slate; compact hematite iron with magnetic brown oxide of iron compose the 'back of the lode'; standing above the grass the strike or level course is N. 28° W., underlaying to the eastward at an angle of 61°. The shaft was sunk perpendicularly 10 fathoms, when it touched the footwall of the lode, which exhibits 'slickensides,' killas backed by elvan; at this point a 'plat' was formed, and a 'drift' cut across the lode to the extent of 30 feet. It is not satisfactorily known whether the 'headwall' or 'hanging wall' was reached. The shaft was then turned down vertically on the drift. The angle has since been cut away, and the back filled in; it now proceeds on the incline of the underlay.

"A plat 15 feet x 12 feet was cut at 16 fathoms; in this plat a 'slide' or 'fault' has shifted the metallic run of the lode 4 feet to the eastward. At this point some very encouraging evidences occur. There has not been any driving on the level course or drift, but merely an extension of the plat.

"At 20 fathoms a level course has been worked 31 feet to the northward and 33 feet southward. The level is 3 feet wide and 6 feet high. A cross-drift 27 feet in length has been made opposite the shaft, at which place the miners pronounce the headwall to be; this is not proved.

"At the north end of the level there is a considerable quantity of soft 'killas,' the joints and laminations of which are filled with beautiful vermilion red oxide of copper 'chalcotrichite' minutely crystalised. This appears to accompany the line of strike or fault. Upon driving about 4 feet in drift the face of the slide was observed. The shaft has been sunk 10 fathoms below. At 30 fathoms water was cut into; at present it is easily kept under by the 'kibble.'

"Of the lode itself, it will be evident, by the description of the workings on level courses, and on drift across the course, that there are 30 or more feet between the two rock walls."

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BATHURST MINING DISTRICT —*continued*.

The mine appears to have been abandoned for a number of years prior to 1876, when Messrs. Samuel and Lloyd reopened it and erected smelting furnaces, one being in blast during that year. Operations were continued during 1877; but in the following year, after considerable unremunerative expenditure, the mine was handed over to the owner, Mr. Icely, who carried it on for a couple of years longer. The main shaft was sunk about 150 feet, and the lode driven on for a considerable distance. It is reported to have been very patchy, the ore bunches sometimes having a thickness of 1 foot or over.

During a visit to the site in 1898 a sample was selected from the old tip, consisting of ferruginous carbonates of copper with garnet rock, for the purpose of testing it for the presence of gold. A trace only was found (under 2 dwt. per ton).

A short distance from the mine, on the same estate, excellent iron ore is now being quarried for the Lithgow iron smelting furnace. Prior to the erection of the latter, the ore was largely used as flux.

Mr. Stutchbury, in 1851, was much impressed with the iron resources of the estate, and wrote :—

"In the great park at Coombing the summits of five small mountains or hummocks (of from 20 to 50 or more acres each) are composed of a very rich compact hematite iron, much of it magnetic.

"A similar ore of iron forms the back of a copper lode on the same estate

"The apparent quantity of iron is so immense, and if all things else were compatible with manufacture of iron, there is sufficient to supply another Sheffield for ages to come. At the present time I would suggest the examination by shaft or level of the interior of one of these mounds, as it is possible that the iron may be laying on the back of a 'room,' or the cross junction of metallic lodes of higher commercial value than the iron.

"Near Mr. Icely's residence, in one of the paddocks, a copper lode has been discovered and opened to some extent, but not more than was necessary to demonstrate its capabilities. In comparison with those I have examined in this Colony, it certainly is of high promise."

In 1900, a shaft was sunk 100 feet in the principal iron outcrop, under aid from the Prospecting Vote. A cross-cut at that level revealed 100 feet of iron ore.

Molong Division.

Copper Hill Copper Mine, part of portion 5, parish Copper Hill, county Wellington, about 2 miles south of Molong.—This was one of the first—if not the first—copper mines opened in New South Wales, its early discovery being doubtless due to its exposed situation close to the old Sydney to Dubbo road, which passed by the side of the hill, where the characteristic green and blue colourations of copper carbonates are still visible in the remaining portions of the rugged outcrop.

Mr. James Rankin states that he saw mining operations in progress in 1845. In 1847 a company was formed to work the lode—Mr. (afterwards Sir Saul) Samuel being managing director. Shafts were sunk 70 and 146 feet, and smelters erected. A quantity of ore was converted into regulus and carted to Sydney, but no records of the amount are available. The company ceased operations in 1851 when gold was discovered. In 1852 Geological Surveyor Stutchbury reported the mine as "deserted" and not accessible." He described Copper Hill as consisting of "elvans" and decomposed clay-slates, followed by porphyries, with occasional altered slates,

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until it joins the granite of Molong mentioned in his former reports. The following information was derived from a Mr. Clymo, formerly manager of the mine. He first describes "Hood's" shaft to be 21½ fathoms (189) feet deep; the first vein or bunch of ore was struck at 45 feet; it consisted of green and blue carbonates with red oxides; a level was driven 180 feet north. The first shaft was sunk alongside a smooth slickensided wall on which were found strings of native copper. Another level or cross-drift was cut 60 feet east, when a lode of quartz and ore was found 9 feet wide, and dipping to the east at an angle of about 20 degrees. Some unsuccessful attempts at smelting had been made, the failure of which Mr. Stutchbury attributed to probably the unsuitable open-mouthed furnaces adopted.

In 1871 the Molong Consols Copper-mining Company was formed, according to local report, on the strength of statements of the large amount of ore available at grass. Three reverberatory furnaces were erected, but only one was charged; but it is evident from its internal and external condition no regulus or refined copper was produced. Practically little prospecting was done by this company beyond surface work.

In $\frac{1845}{1850}$, C. S. Wilkinson, Government Geologist, visited Copper Hill, and described it as a huge mass of felsite, with hornblende porphyry in places, traversed by numerous lodes or dykes of porous ferruginous quartz. In connection with the latter, it is interesting to note that the late Mr. J. E. Kelly, on whose estate the hill occurs, submitted 14 tons from it and neighbouring outcrops to battery treatment for a return of 4 dwt. of gold per ton. A sample of the copper ore lying at surface was selected by the Writer, but yielded under 2 dwt. of gold per ton by assay.

About 1888 a Newcastle syndicate carried on a little surface prospecting higher up the hill.

A good deal of copper carbonate is mixed in the fines and screenings from the old workings, but are unsuitable for direct furnacing. The outcrop has a very deceptive appearance at a distance, owing to the strong blue and green colourations in sheltered crevices and excavations, arising from the internal leaching of the thinly-distributed copper ores and redeposition in the form of sulphates and carbonates in sheltered spots by evaporation of the percolating solutions.

The Copper Hill Copper-mining Company was formed in 1907. After unwatering and prospecting the mine was abandoned, and the machinery removed; nothing workable being discovered.

Oberon Division.

Copper Hill (Foran's) near Wiseman's Creek.—Old workings reopened by two new shafts following underlay in oxidised zone only.

Lode in the principal new shaft strikes north and south and dips east at 38°, and consists of about 1 foot of dredgy quartz and country with copper carbonates. The workings extend over a distance of about 200 feet.

A sample of the dressed ore at grass yielded:—

No. 08-915—Copper	9·22 per cent.
Gold	a trace per ton.
Silver	2 oz. 3 dwt. 13 grs. ,,

Two loads of ore despatched in July, 1907, were reported to have yielded 16·4 per cent. at Lithgow.

Copper Mine Creek.—See p. 274.

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Tuena Division.

Cordillera Hill, parish Tuena, county Georgiana.—Mr. Warden T. A Smith states that this lode was discovered in the early 80's by Phillip Hyde. The Cordillera Hill Silver-mining Company, which started operations during the silver boom of 1888, extracted 222 tons of copper from their silver ore during that year. The exact figures, according to the Warden, $\frac{1888}{p.\ 555}$, being: 9,000 tons of ore treated, yielding 82,800 oz. of silver, 404 oz. of gold, 227 tons of lead, and 222 tons of copper, valued at £37,343.

A depth of about 180 feet was reached before closing down in 1889.

The kindly gossan ores of the outcrop at Cordillera, just as those of the neighbouring Mount Costigan and more distant Lewis Ponds and Sunny Corner mines, gave place at water-level to refractory mixtures of sulphides of zinc, lead, iron, copper, and arsenic, of low grade, which so far have baffled every attempt at profitable working, especially since the serious fall in silver value.

It is noteworthy that scheelite (tungstate of lime) and stolzite (tungstate of lead) occur in the Cordillera Mine.

(Reopened in 1907 by the Mt. Costigan and Cordillera Company. Under suspension in 1908.)

Rockley Division.

Cow Flat Copper Mine, about 7 miles from George's Plains Railway Station.—According to Captain W. R. Reynolds, the first ore raised from Cow Flat was shipped to England. The earliest official record is contained in the Annual Report of the Department of Mines for 1875, p. 59. At that time eighty men were employed, and a statement is made that the yield had not decreased during the past twelve months, considering the number of men employed. Six furnaces had been erected, but only two were in use, owing to the sheds being leased to the Esk Smelting Company, who reduced the ore to regulus, and forwarded the latter to their refining works at Lithgow.

In 1872 the mine was floated into a public company by Mr. S. L. Bensusan.

In $\frac{1871}{p.\ 210}$ Mr. C. S. Wilkinson reported that "the general formation of the Cow Flat district consists of Silurian sandstones, shales, limestones, and talcose, chloritic, and micaceous schists, traversed by numerous quartz reefs, some of which are of great thickness, and termed by the miners 'blows.' The general strike of the strata and reefs is N. 25° W., dip easterly, though near Bell Creek they strike N. 30° E., and dip westerly. Copper ore occurs in many of the reefs. The green and blue carbonates of copper are generally found near the surface, and passing downwards the black oxide, or 'coated' ore, is met with, and below this the grey and yellow sulphurets with galena; occasionally the red oxide and a little native copper are found. The irregular and uncertain mode of distribution of these ores is the chief cause of so much fluctuation in the copper-mining industry of the district."

In $\frac{1878}{p.\ 97}$, the Mining Registrar reported that thirty men were constantly employed during the year, 80 to 100 tons of ore per month being raised of an average value of about 8 per cent., which was disposed of to the Esk Smelting Company at about 60s. per ton. Depth of shaft, 180 feet; lode, from 6 inches to 10 feet in thickness.

In $\frac{1879}{p.\ 72}$, the work performed was not equal to that of former years, owing to the low price of copper. About 220 tons of ore were raised, which yielded 20 tons of copper, valued at £1,100.

In 1880 the mine was leased to Mr. Lewis Lloyd. A new shaft was sunk 72 feet, about 400 yards from the old workings; the result, however, was

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not as satisfactory as expected, the lode was well-defined and 2 feet thick, but the grade was low. 376 tons of ore were raised during the year, and sold to the Bowenfels Smelting Works for £813.

In 1881 three new shafts were being sunk. The deepest level in the mine was 180 feet. 387 tons of ore were raised, and sold for £876 17s. 3d. Being smelted at Lithgow, it yielded 28 tons of copper, valued at £1,620.

The Cow Flat lode has a very strong iron outcrop, which doubtless induced hopes of good things below, unfortunately not to be realised so far as testing has proceeded. The lode, judging from the outcrop, practically consists of hornblende and choritic schists impregnated with iron and a little copper pyrites, which under atmospheric influences have become converted into iron oxides and copper carbonates for shallow depth only, for the unaltered sulphides are visible in the open cuts. A sample of the unaltered pyrites selected from one of the shaft tips during a visit in 1898 yielded 5·20 per cent. of copper and a trace of gold (under 2 dwt. per ton).

In 1900, according to the Annual Report of the Department of Mines, p. 55, the Cow Flat lode was secured by a syndicate, which continued prospecting for some time. Frequent small bunches of ore were met with; 400 tons raised, valued at £400.

Cow Flat District.—In 1899 Inspector Polkinghorne reported on an application for aid (P.B. $\frac{1}{0}\frac{8}{0}\frac{1}{0}\frac{2}{2}$) for a site about 1½ miles north-west of Cow Flat Mine, carbonate of copper having been extracted from old workings some years previously. Aided to sink from 15 feet to 100 feet. Sank 50 feet, then apparently abandoned, there being no further record.

Dolomite mixed with calcite, about 3 miles from George's Plains, is being quarried for basic lining in the iron smelting furnace at Eskbank :—

Composition—Carbonate of lime ($CaCO_3$)	54·28
,, magnesia ($MgCO_3$)	39·34
Alumina and oxide of iron ($Fe_2O_3 + Al_2O_3$)	0·46
Gangue	5·78
	99·86

Mount McDonald Division.

Cowra District.—Ballantyne and party's shaft, G. Lockyer's private land, parish Cowra, county Bathurst, 3 miles east-north-east from Cowra.

Inspector G. Smith reported (3rd November, 1906) copper ores in quartz porphyry—striking east and west, and dipping south. Depth of shaft 46 feet. Length of outcrop 300 yards.

Blayney Division.

Diamond Hill, Guyong.—J. H. Glasson's private land. Copper lode reported traversing this property, containing a little gold. Opened to a depth of 100 feet by three shafts; driven 60 feet. (Annual Report, Department of Mines, 1902, p. 49.)

Rockley Division.

Dolcoath Mine, 3½ miles north of Essington, about half a mile west of Mount Stromlo, on north side of Stony Creek.

Inspector H. Hooke reported (P.B. $\frac{1}{0}\frac{8}{0}\frac{2}{2}$) copper vein traversing hard schistose rock. Veins small, in channel a few feet wide. Aided to sink 100 feet. No record after 24 feet; probably abandoned at that level.

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Bathurst Mining District—*continued.*

Burraga Division.

East Burraga Mine, parish Jeremy, county Georgiana. Strike N. 10° W. dip S. 80° W. at 55°.

Several shafts sunk, representing extensive prospecting in and near a small ferruginous outcrop resulting from oxidation of pyritic strata. The pyrites, however, at low levels is not solid enough for pyritic flux, and, moreover, is very silicious.

A little silicious carbonate ore is at grass, but was evidently in very limited quantity.

An average sample of the ore yielded :—

No. 08-907—Copper, 0·37 per cent.
Gold, a trace per ton.
Silver, 2 oz. 3 dwt. 13 grs. per ton.

Mount McDonald Division.

Eldorado Copper Mine.—South of, and adjacent to, Millburn Creek Mine. Parish Dunleary, county Bathurst. Inspector Hooke reported (September, 1901) strike of lode north and south, vertical in schist. Width 9 inches to 2 feet. Three shafts sunk 20, 42, and 44 feet, about 50 feet apart.

Yield to that date—8 tons "firsts," assaying 20 per cent. copper; 12 tons "seconds," estimated 10 per cent. copper.

Bathurst Division.

Esmeralda Copper Mine, 3 miles from George's Plains Railway Station, M.L. 254, parish Ponsonby, county Bathurst.—Discovered by T. Tonkin about 1877, and opened to about 50 feet. Strike N. 33° E.; dip N. 57° W. at 78°.

Reopened by J. Thomas and party, May, 1906, who drove south 50 feet from bottom of old shaft, and despatched from it 18 tons of ore, returning 9 per cent. copper.

The Esmeralda Syndicate took over mine, July, 1907, and deepened shaft to 68 feet at time of inspection, December, 1907. An average sample from about 12 tons of dressed ore at surface, and the screenings therefrom, gave the following results on partial analysis :—

	No. 07-7945—Dressed ore.		No. 07-7946—Screenings.	
Copper	11·06 per cent.		6·37 per cent.	
Zinc	11·61 „		6·91 „	
Iron	16·52 „		11·62 „	
Sulphur	21·64 „		12·09 „	
Silica	24·20 „		36·50 „	
Gold	a trace.		traces.	per ton.
Silver	3 oz. 5 dwt. 8 grs.		1 oz. 12 dwt. 16 grs.	per ton.

The country consists of micaceous and hornblendic schist, with garnets. The ore of copper pyrites and zinc-blende, mixed with country in part; width, 3 feet to 4 feet. Pinched at south end, but going under foot. At 68 feet level, from 2 feet 9 inches to 3 feet of sulphides occur.

About a quarter of a mile south on strike quartz was quarried for furnace bottoms at the old Cow Flat furnaces; stains of copper carbonate are sparingly present in the quarry.

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Bathurst Mining District—*continued.*

Rockley Division.

Essington.—Hope and party's shaft, portion 31, parish Adderley, county Westmoreland. Opened in 1907 to a depth of about 70 feet on underlay. Vein of silicious copper ore, a little of which was sent for sale. Quartz with carbonates in chloritic or hornblendic schist. Strike N. 10° E., dip west.

Fitzroy Mine.—See p. 275.

Fullback Mine (originally the *Dingo*), M.L. 1, parish Baring, county Westmoreland.—Opened many years ago; reopened in 1907. (Closed at date of inspection in March, 1908.) Unable to descend on account of foul air. Worked by whim. Average width of lode reported, 1 foot 6 inches to 2 feet. Strike apparently N. 10° W., dip S. 80° W. at 64° in hornblendic schist, close to junction of quartz felsite. No apparent outcrop. Some good grade dressed ore at grass, the quality of which is represented in the following assay :—

No. 08-918—Copper	17·37	per cent.
Zinc	1·24	,,
Iron	26·04	,,
Sulphur	22·53	,,
Silica	18·50	,,
Gold	a trace	per ton.
Silver	1 oz. 6 dwt. 9 grs.	per ton.

About 25 chains N. 20° W. from Fullback Mine two shafts in similar country have been sunk about 50 feet apart on a very flat-lying vein of quartz with carbonates about 12 inches thick, striking N. 10° W., and dipping S. 80° W.

According to the Annual Report of the Department of Mines, 1901, p. 54, about 200 tons of ore were disposed of during that year from the Fullback Mine, being sold to the Lloyd Copper-smelting Works at Lithgow.

In 1907 the old shaft (300 feet) was cleaned out, and 11 tons despatched in May are reported to have yielded 15 per cent.

Orange Division.

Great Western Copper-mining Company, Icely.—The prospectus of this company, issued by Mr. S. L. Bensusan in November, 1872, embraced a number of lodes previously opened and partly worked near Byng and Lewis Ponds. The first half-yearly report, dated February, 1873, enumerated these as follows :—The Britannia, Icely, Belmore, Moonta, Nelson, Gurophian, East Block Mines, and other property to the south. (*See* Carangara Mine.)

In Mineral Statistics, $\frac{1^{st}}{p.}\frac{I.}{1}\frac{A.}{}$, it is stated that the company was working the following lodes at Icely, viz. :—The "Williams" lode having a thickness of $2\frac{1}{2}$ feet at surface, 5 feet at 125 feet, and 3 feet at 270 feet Strike N. 30° W., dip easterly; 4,000 tons of ore raised yielded 560 tons of copper.

The Icely lode was proved to a depth of 125 feet; average thickness, 1 ft. 6 in. Strike N. 30° W., dip 1 in 6 easterly; 1,000 tons of ore raised yielded 100 tons of copper.

The company held several other lodes, four of which had been worked, the strikes and dips being similar to the Icely and Williams lodes; 100 tons of ore raised from them yielded 12 tons of copper.

The company was also working eight lodes at Lewis Ponds Creek; average thickness, 3 feet. Strikes N. 20° W., and dips about 1 in 5 easterly; proved to 168 feet; 4,000 tons of ore raised yielded 640 tons of copper.

According to Captain W. R. Reynolds, at one time mine-manager for the company, smelting-works were erected in connection with the Icely Mine,

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at which the ores from the others were treated. The company also purchased ores at the rate of 10s. per unit for all over 4 per cent., the latter amount being deducted in lieu of smelting charge.

Captain Reynolds also supplied the following particulars of the mines that came under his supervision during the operation of the company, which were worked chiefly by contract instead of day-labour:—

	Opened to.	Thickness of lode.
Icely	275 ft.	1 to 4 ft.*
Ophir	about 200 ,,	6 in to 5 ft.
Gurophian (afterwards Tom's Lewis Ponds)	,, 170 ,,	9 ,, to 4 ,,
Britannia	,, 210 ,,	3 ,, to 5 ,,
Belmore	,, 180 ,,	1 ft. 6 in.
Moonta	,, 60 ,,	.....
Nelson	,, 120 ,,	1 ft.

* Worked ten years.

Mr. F. Danvers Power states, that at the Mt. Fraser Mine, near Byng, a new shaft was sunk 110 feet; driven south, 109 feet, north 100 feet, with rise to meet winze in old workings. A sample taken along 110-foot level, 8 in. wide, assayed by Mr. A. Orr, yielded copper 6·46 per cent.; silver, 1 oz. 13 dwt. 6 grs. No gold.

Bathurst Division.

Green Swamp Mine, M.C.P. 112, parish Yetholme, county Roxburgh, about 13 miles from Bathurst, close to Sydney road.—Specimens from this lode are reported to have been exhibited at the Crystal Palace Exhibition in 1851.

About 1898 it was reopened by a syndicate, who sank a shaft and drove a tunnel at the north end. From the eastern lode, cut in a crosscut at the 55-feet level in the main shaft, 25 tons of oxidised ore were despatched for a reported yield of 8 to 12 per cent. of copper. From a small underhand stope in the tunnel, 15 tons are reported to have yielded 14½ per cent.

The mine was again opened in the early part of 1907, and 10 tons extracted are reported to have yielded a little over 10 per cent. at Blayney.

In January, 1908, the Amalgamated Green Swamp Copper Mines, Limited, was formed to work the property.

Strike of main lode about N. 17° W., dip N. 73° E. at 30°.

The developments to date are two main shafts—"Hyde's" and "South"—depths 135 feet and 110 feet respectively. Sixty-one feet south of the latter is a 61-foot shaft, used as a ladder-way, and connected at bottom with the South shaft.

From the South shaft a cross-cut east is being driven to intersect the east lode; the shaft having been sunk in a joint fissure underlying west, without ore. A little ore was cut in chlorite schist when the east cross-cut was started, thence all in hard felsite, which appears to form the footwall side of the east lode.

The main, or "Hyde," shaft lies about 250 feet north of the South shaft. At 55 feet a cross-cut east furnished the ore despatched. At about 112 feet a cross-cut east, after passing through the felsite, cut about 13 feet 6 inches of low-grade sulphide ore, of about 2 per cent. grade. In the bottom of the shaft the best ore exposed occurs about 2 feet wide on footwall. A greater width is lightly impregnated with copper, but is very hard and of low grade.

Above the 55-feet level in the South shaft is an area of stoped ground, about 35 feet long by 30 feet high.

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BATHURST MINING DISTRICT—*continued*.

Between the main shaft and the tunnel on the north—about 400 feet—are two shallow shafts, one connecting with the tunnel, where the latter first cuts the lode. The tunnel, if continued, would about reach the bottom of the deepest shaft (Hyde's), 135 feet.

There appear to be three parallel lodes in this site, two of which have been opened.

The country consists of chloritic, or hornblendic schist, and felsite. Dolomite and calcite occur in small nodules and veins. The sulphide ore is of good grade, when clean, but is much mixed with country.

An average sample of bagged ore at Hyde's shaft gave very disappointing results on assay :—

No. 08–908—Copper	1·62	per cent.
Iron	19·32	,,
Sulphur	10·96	,,
Silica	17·88	,,
Gold	1 dwt. 2 grs.	per ton.
Silver	14 ,, 3 ,,	,,

A sample of the dolomite yielded the following composition :—

No. 08–923—Carbonate of lime	45·91
Carbonate of magnesia	34·63
Ferric oxide and alumina	4·18
Gangue (quartz)	15·12
	99·84

Molong Division.

Gumble, L., M.L. 7, parish Manildra, county Ashburnham, about 4½ miles from Manildra Railway Station.—The Gumble lode affords one of the rare instances in the State of the association of tin and copper ores in the same lode; other instances being Bald Nob, near Emmaville, and Royal George, near Tingha. Unfortunately at Gumble neither metal is sufficiently represented to pay for working.

The most deceptive feature to miners in this lode is the dissemination of magnetic iron oxide in small grains, which imparts to it considerable gravity, leading to the belief that the latter is due to cassiterite (tin oxide).

A concentrating test made at Parke and Lacy's works, Pyrmont, during operations at Gumble, was reported to have been successful in producing concentrates containing 60 per cent. of tin and 15 per cent. of copper, but this statement is discounted by the absence of any data and the closing of the mine.

The following description is from the Report of the late Government Geologist, C. S. Wilkinson, $\frac{1}{p}\frac{8}{1}\frac{5}{3}\frac{6}{2}$:—

"The lode commences at the junction of granite and altered Silurian slates, and traverses the latter for about 100 yards in a N. 30° E. direction. It varies in width from 1 to 8 feet, and consists of ferruginous felspathic and silicious lodestuff, more or less impregnated with green and blue carbonates, grey sulpides, and red oxide of copper, brown oxide of tin, and magnetite. The tin ore principally occurs in the central and southern portions of the lode. . . . .

"In a drive on the 100-feet level on the eastern side of the lode, for a distance of 15 feet, the country rock, altered rubbly shales, with serpentine in the joints, is found to be impregnated with native copper in bright crystalline small grains and scales; and on the west side, at the 60-feet level, the rock for a distance of 14 feet is in places stained with carbonate of copper. It is thus evident that the rock on both sides of the lode has been more or less affected by the agencies, probably thermal water holding minerals in solution, which formed the lode. . . . .

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BATHURST MINING DISTRICT—*continued.*

"Seven average samples taken by myself across the lode yielded on assay at the rate of copper traces to 2·85 per cent., tin traces to 0·5 per cent., and silver traces to 4 oz. 1½ dwt. per ton.

"A sample of the country serpentinous rock showing native copper, assayed 4·2 per cent. of copper, with traces of tin and silver.

"One picked sample of brown ore showing tin oxide and carbonate of copper from the lode at the 60-feet level, south drive in the middle shaft, yielded on assay—copper, 3·85 per cent.; tin, 58·70 per cent.; silver, 8 oz. 19½ dwt. per ton.; and no gold. It is thus seen that the ores occur in patches, and not disseminated regularly through the lode.

"Three-quarters of a mile south from the Gumble Mine, and at the line of junction of the Silurian and the granite, a lode somewhat similar to the Gumble lode occurs. It consists of soft felspathic lodestuff, with yellowish-green silicate of iron, silicious clinker, and hard quartzite, with quartz veins containing pyrites, and a little fluorspar, together with carbonates and sulphides of copper.

"About 20 chains further south occurs another outcrop of quartz containing carbonates of copper and fluorspar, which should be prospected."

Copper ore is also mentioned as occurring in altered slates and limestones about 1 mile north of Red Hill (1½ miles north of Gumble).

Inspector H. Hooke reported (P.B. $\frac{\text{A}\,\text{S}\,\text{A}}{0\,0}$) that three shafts had been sunk about 90 feet; lode being traceable for about a mile. Aid granted to sink from 84 feet to 158 feet. At 143½ feet fair prospects were reported, but not payable. Lode 16 feet wide. Driven 40 feet at 140 feet. No further sinking. Balance of aid cancelled.

Inspector Polkinghorne reported (P.B. $\frac{\text{A}\,1\,1\,0}{9\,9}$) carbonate of copper and oxide in decomposed formation in portion 64, parish Gumble, county Ashburnham, about 14 miles west from Molong on Gumble road. Aided to sink 100 feet. At 55 feet good bunches of ore, but not in payable quantity.

Orange Division.

Hawk's Nest Lode.—Portion 15, parish Byng, county Bathurst, alongside Orange road, near Byng. Three lines of copper-bearing strata occur in this locality. The western stretching from Diamond Hill to Rats' Castle shafts; the centre, or Hawk's Nest line, about 10 chains east; the east, or Thunder Castle, about 9 chains further east.

The Diamond Hill outcrop is reported to have been opened by a Melbourne company in 1903.

About 3 miles north-westerly along the same belt the "Oaky-Smut" shaft was sunk 100 feet, and about three-quarters of a mile further, the Rats' Castle shaft to 40 feet. Between the two latter a little copper ore has been superficially exposed about S. 50° W. from the Hawk's Nest shaft.

The Hawk's Nest lode was discovered by W. Thomas and party in 1907, and opened to a depth of 60 feet by February, 1908. It strikes N. 50° W., and dips N. 40° E. at 67°.

At the south end of the shaft at 60 feet, about 3 feet 6 inches of good sulphide ore, mixed with country, made fairly solid on the hanging-wall side, but died away in strings on the foot-wall. Country consists of chlorite schist. . . . . .

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BATHURST MINING DISTRICT—*continued.*

Forty tons of dressed ore sent to Blayney averaged 10 per cent. of copper and a trace of gold.

The "Thunder Castle" line is reported to have been opened about 40 years ago. A little copper ore shows at surface.

Cowra Division.

Holmwood Copper Company.—About half-a-mile from Holmwood Railway Station, and 4 miles east-north-east of Cowra, on G. Lockyer's land, parish Coota, county Bathurst.

Inspector G. Smith reported (P.B. $\frac{1899}{06}$):—"Copper veins in porphyry (?). Four of these occur at the site some little distance apart. A shaft has been sunk in the middle in solid country in expectation of intersecting some of the veins on their underlay.

"One of the veins opened contains bunches of copper ore, and is from 12 to 18 inches wide. An assay of the ore yielded :—

No. 06-5933—Copper, 8·22 per cent.
Gold, 3 dwt. 6 grs. per ton.
Silver, 3 dwt. 6 grs. ,,

"Aided to sink to 62 feet. At 58 feet it was reported that lode formation continued down in the shaft, and was impregnated with green carbonate at bottom. (No further record.) Reported output, 60 tons."

Holmwood.—Two miles south of Holmwood Railway Station, on Mr. Campbell's land.

Inspector J. James reported (P.B. $\frac{1869}{03}$) :—"A copper lode in slate and diorite, striking north and south ; with a vein of copper carbonate 3 inches to 8 inches wide.

"Aided to sink to 50 feet. At 33 feet cupriferous formation about 17 inches wide ; country hard. At 50 feet copper ore making in south end. Aided for 25 feet of driving at south end. Driven 10 feet, a little ore showing. No further record."

Rockley Division.

Hopeful Mine.—Half a mile from Phœnix Mine ; 8 tons of carbonate ore raised, yielded 17 per cent. copper.

Orange Division.

Icely Mine, parish Byng, country Bathurst.—Since the first edition of this work the water was baled out of this mine, and an attempt made to precipitate the copper in solution by the local Payne process, but was not financially successful.

Carcoar Division.

Infirtaris Copper Mine, parish Beaufort, county Bathurst.—In private land close to Growanbang Station Homestead.

Inspector G. Smith reports that it was found by a Chinaman, whilst prospecting for alluvial gold, about 1880.

Patches of copper and iron pyrites occur in andesite. Strike E. and W., dip S. ; width not apparent. Maximum length of proving, 80 feet ; depth, 90 feet. Gross output 30 tons of 11 to 12 per cent. copper ore ; no gold or silver.

Mr. E. R. Cocks who worked the mine states that the ore recorded was extracted from a patch 16 feet. No other stoping or driving done. A little ore showing in a cross-cut at 60 feet. Not much at 90 feet.

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BATHURST MINING DISTRICT—*continued.*

Rockley Division.

Integrity and Murphy's lode, M.Ls. 9 and 7, parish Baring, county Westmoreland.

This lode, striking N. 20° W., and dipping S. 70° W., has been reopened by new shafts in Wilson and Murphy's leases.

In Murphy's (M.L. 7) the new shaft is down 140 feet, exposing a width of 1 foot 6 inches to 5 feet, with strings and bunches of good sulphide ore making in places about 1 foot 6 inches wide. A quantity despatched yielded 10 per cent. of copper. Ore silicious, but copper sulphide pure when clean.

The *Integrity Mine* (Wilson's) in M.L. 9 adjoining, was down 80 feet in March, 1908. The lode here runs from 3 inches to 10 inches in width, and consists of very silicious sulphide, with a little calcite.

The country is chloritic schist near junction of quartz-felsite.

Jackass Mine.—Portion 208, parish Irene, county Westmoreland. Held under authority to enter; about 4 miles east of Rockley. Shaft 200 feet, driven north and south at 80 feet level. Small irregular lenses of copper ore. Eight tons sent to Lithgow averaged 8 per cent. Abandoned.

Aid granted (P.B. $\frac{2}{0}\frac{2}{0}\frac{1}{0}\frac{1}{0}$) to continue shaft from 100 to 160 feet. At 130 feet several small veins of copper ore cut dipping east. At 188 feet an eastern cross-cut driven 18 feet. Further aid refused.

Jocelyn Mine.—Wiseman's Creek, parish Jocelyn, county Westmoreland. Opened about 1882 to a depth of 70 feet; reopened by new shaft in 1907 to a depth of 103 feet. Channel about 2 feet 6 inches wide; well defined in hornblendic or chloritic schist. Through the crushed channel rock filling, strings and kernels of calcite with copper sulphide occur.

Unless the copper ore becomes more solid and persistent, a large amount of material will need to be extracted for a comparatively small percentage.

Three tons dispatched yielded 14·5 per cent. of copper.

The channel strikes N. 25° W., and dips N. 65° E.

The original Jocelyn shaft was sunk on another vein, about N.E. of the present working shaft.

Mount McDonald Division.

John Bull Mine.—Three miles east of King of England Mine, and 18 from Cowra, parish Bang Bang, county Forbes.

In 1905, Peel and party sank 35 feet, and raised 4 tons of ore assaying 25 per cent. copper. In 1906, the shaft was deepened to 100 feet, and driven north about 30 feet.

The ore—grey sulphide—occurred in a pipe-like formation, about 9 feet long and 3 feet wide. At 100 feet level the ore became stringy, and water began to make.

The output during 1906 was:—

7 tons 1 cwt. ..... yielding 19·78 per cent.
15 tons ..... ,, 23·5 ,, } At Waratah.

Bathurst Division.

Jones' Mine, Mount Morris.—About 1½ miles easterly from the Apsley Copper Mine, near Cow Flat, and about 3 miles from Lagoon; opened a number of years since, and ore despatched; shaft 70 feet.

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Keloshiel, near the village of Eglinton.

Mr. James Ranken states that, in 1850, his father had a small well deepened at the Keloshiel Brewery. In blasting the rock, pieces of dark-blue copper ore were obtained. Concerning this discovery, Mr. S. Stutchbury reported, on 12th April, 1852, that "a copper lode was discovered by Mr. Ranken at this place [Keloshiel.—J.E.C.], while sinking a well for his brewery, at a depth of 20 feet. He showed me good specimens of green and blue carbonate of copper; and, as a proof that it must be of some extent, the water of the well continues so much impregnated with it as to render it unfit either for brewing or culinary purposes." No attempt has since been made to open up and prospect the source of the specimens and impregnated water.

Carcoar Division.

Kempfield Station, Gully Swamp.—Copper lode at Kempfield Station, worked by Lane and party, was reported to have promised well. Two parallel lodes occur. Samples assayed ($\frac{1}{8}\frac{A}{8}\frac{n}{8}$) yielded from 23 to 27 per cent. of copper.

This mine was secured by the Lyndhurst Railway and Mines, Limited, in 1903, and prospected for a time with a view of obtaining cupriferous flux for the Lyndhurst Gold Mines. Apparently, results were not satisfactory.

Orange Division.

Lady Belmore Mine, Lewis Ponds, portion 39, parish Worcester, county Bathurst.

Strike N. 10° W. Channel about 3 feet wide, filled with crushed quartz-felsite, and quartz; the latter being dredgy and containing copper sulphide and black ore (sub-sulphide).

Lode opened many years ago by four shafts extending for about 4 chains along the strike. A cross-cut tunnel 288 feet long intersects the lode at about 100 feet below the outcrop. At this depth a level has been driven for several hundred feet along the lode, the principal shafts being connected with it. Stoping has been carried up wherever shoots of payable ore occurred. The amount of ore extracted is not recorded.

Recently the mine was reopened at the tunnel level, and driven southerly for a short distance. The face showing about 1 ft. 6 in. of quartz and 2 ft. 6 in. of crushed quartz-felsite with strings of ore.

An average sample of this partially-enriched ore yielded:—

No. 08-569—Copper, 6·55 per cent.
Gold, a trace
Silver, 4 dwt. 8 grs. } per ton.

Little Bell Mount, portion 8, parish Worcester, county Bathurst, 2 miles south of Lewis Ponds.

Inspector G. Smith reported in 1906: Copper carbonates in slate discovered by M. Gleeson and T. Davis (old workings on same line in adjoining ground).

Strike, N. 30′ W.; dip, N. 60′ E.; width 8 to 10 inches. Depth of proving, 90 feet; length of lens, 23 feet.

Output, 3 tons 9 cwt., averaging 16 per cent. copper; 2 tons at grass.

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BATHURST MINING DISTRICT—*continued*.

Little Gem Mine, Mount Ragan, near Lewis Ponds. M.L. 6, parish Worcester, county Bathurst.

Strike, N. 20° W.; dip, N. 70° E., in schist. Opened by two shafts, 40 and 46 feet deep, and 35 feet apart, connected at 40 feet.

About 6 inches of grey ore for a length of about 9 feet between shafts, backed by about 2 feet of country with splashes of black ore, probably chalcocite.

At the bottom of the 46-feet shaft, yellow sulphide is showing in fine strings on hanging wall side, making stronger on footwall at south end partially enriched black ore.

The quality of the ore is demonstrated in assays of average samples :—

No. 08-578—Enriched ore from bottom of 46-feet shaft—
Copper, 27·35 per cent.
Gold, a trace
Silver, 6 oz. 12 dwt. 20 grs. } per ton.

No. 08-579—From end of 46-feet shaft—
Copper, 12·88 per cent.
Gold, a trace
Silver, 8 dwt. 17 grs. } per ton.

Bathurst Division.

Locksley, about 1½ miles north-east of the Locksley Railway Station, on the Great Western Railway Line.—Opened about 1888; reopened in 1898. Shaft 80 feet deep. Lode reported to have cut out. Walls well defined.

In 1907 Mr. Francis Drake partially unwatered the old workings. The lode strikes E.N.E. in granite. At 70 feet a bunch of sulphide ore was encountered. A little driving had been done to the W.S.W.—about 15 feet—in ore of very low grade.

It is reliably reported that at 94 feet a level was driven 50 feet E.N.E. along the lode, which at the end had narrowed to 6 inches. From this level stoping was carried up 20 feet.

At 100 feet the lode is reported to have cut out on a solid granite floor. No further sign at 110 feet.

Oberon Division.

Louther, 15 miles from Mount Victoria.—Copper and silver ore was discovered hereabouts in 1897, which yielded ($^{*}\frac{1}{0}\frac{1}{7}\frac{7}{7}$) 39·9 per cent. of copper and 15 oz. 5 dwt. 23 grs. of silver per ton; a further sample ($\frac{1}{0}\frac{8}{8}\frac{3}{8}$) yielded 32·24 per cent. of copper and 20 oz. 18 dwt. 21 grs. of silver per ton but, unfortunately, a workable deposit could not be found. Samples from Garbenang Road, Louther, which is probably identical with the copper locality ($\frac{2}{0}\frac{7}{8}\frac{0}{8}\frac{0}{8}$, $\frac{2}{0}\frac{7}{8}\frac{0}{8}\frac{1}{8}$, and $\frac{2}{0}\frac{8}{8}\frac{3}{8}\frac{8}{8}$), yielded from 19 to 23·5 per cent. of copper, and 5 to 6 oz. of silver per ton.

Rockley Division.

Lucky Hit Mine, 6 miles from Rockley, on west side of Trunkey road, about 1½ miles from old Summerhill Mine, on Mrs. Shepherd's land.

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BATHURST MINING DISTRICT—*continued*.

Inspector B. Sawyer inspected in 1904. Aid granted to sink from 48 feet to 80 feet (P.B. $\frac{12}{04}$). Work discontinued at 89 feet as prospects were not sufficiently encouraging.

Inspector D. Milne reported (P.B. $\frac{12}{03}$) the lode to consist principally of quartz, hard and of poor character, with small bunches of pyrites. Further aid refused.

Mandurama Division.

Mandurama.—About 4½ miles north-west of Mandurama and 3 miles south of Burnt Yards. Mr. J. A. Watt, Geological Surveyor, reported that blue and green carbonates of copper were plentifully scattered through andesitic rock at this site, from the surface down to the depth attained, 27 feet, and that the prospects were favourable. Aid was granted to sink 77 feet and drive 50 feet on the course of the lode. The result of this exploration, however, did not sustain the surface indications. No sign of a lode was visible. The occurrence of copper in the Carcoar andesite and its deceptive indications have been specially alluded to in this work.

Mount McDonald Division.

Milburn Creek Copper Mine, parish Dunleary, county Bathurst.—This mine has had an eventful history, involving both legal and political issues. Briefly stated, the cause of trouble was a disputed title, as set forth in a petition presented to Parliament, in the 1873–4 Session, on behalf of one Robert Martin (Vol. IV, Parliamentary Proceedings, p. 857). Therein it is stated that petitioner selected a mineral conditional purchase at Milburn Creek, on or about the 15th September, 1872, entered into possession and commenced work. At time of survey his right was disputed by Baker and party, to whom subsequently a lease was issued by the Department of Lands prior to the formation of the Department of Mines. Baker and party erected three reverberatory furnaces about 1 mile from the mine, and extracted a considerable amount of copper. Their title to the mine was, however, upset by the Supreme Court. Compensation was granted in 1879 to Baker and party for loss of lease granted to them. The distribution of the sum voted by Parliament to the Milburn Creek Copper Mining Company (which was floated by Baker and party after the lease was secured by them) caused so much dissatisfaction and adverse comment amongst certain shareholders, which was intensified by the explanation offered, that Parliamentary notice and action was invoked, followed by the appointment of a Royal Commission of Inquiry, the results of which are matters of political history. Naturally, these proceedings cast a shadow on the mine as an investment, notwithstanding that the inquiry revealed the existence of proved bodies of sulphide ores of good grade.

Probably the first ore raised from the mine is represented by the following parcels sent to the Newcastle Smelting Works in June, 1873:—

2	tons	13	cwt.	.....	18½	per cent. copper.
2	„	4	„	.....	9	„ „
2	„	7	„	.....	25½	„ „
4	„	11	„	.....	11½	„ „
3	„	13	„	.....	22½	„ „
3	„	17	„	.....	19½	„ „
2	„	2	„	.....	23	„ „

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The Milburn Creek Copper Mining Company consisted of 72,000 shares of £1. Soon after its formation a furnace was erected, brick and fireclay being obtained from Bowenfels for the purpose.

At the second annual meeting of directors for the year ending 30th June 1876, 1,445½ tons of ore were reported to have been raised, of which 500 tons of 13 per cent. ore were smelted for 67 tons of copper, the balance of the ore—945½ tons—were sold to the Esk Smelting Company, Bowenfels, for £4,001, averaging 11¼ per cent. Forty men and boys were then employed.

An arrangement was made during the year with the Esk Smelting Company to rent the Milburn Creek Company's furnace, and to erect two additional furnaces, and to purchase all the latter Company's copper ore on an agreed scale of prices.

A portion of the lower level of the mine was let on tribute (in yellow ore). A lode of black ore at the south end of the workings was averaging 16 to 21 per cent. of copper.

The directors report at the third annual meeting ending June 30, 1877, states that the mine was worked up to within a few days of the above date, when it was suspended pending the Supreme Court decision as to the validity of the lease.

During the year ore to the value of £6,697 was sold to the Esk Company, and 200 tons were at grass.

The following description of the mine and its workings is from the report of the late Under Secretary for Mines, Mr. Harrie Wood (Ann. Rept. Dept. of Mines 1878, pp. 23-24):—

"The mine is situated in lightly timbered box ranges, composed of altered (Upper Silurian) slates and sandstones, dipping W. 10° S. at about an angle of 70°. About three-quarters of a mile from the mine the slates give place to ternary granite, while in a W.S.W. direction the nearest granite is distant about 1½ mile. It will thus be seen that the copper lodes occur in a belt of altered slates, bounded by granite. The surface indications of the several lodes are characteristic. They appear as quartz veins, containing much gossan (the result of the decomposition of copper and iron pyrites), and a few stains of carbonate of copper.

"At a slight depth the gossan gives place to carbonates and oxide of copper, while below these appear the sulphides, &c.

"The greater part of the work done in the Milburn Creek Mine has been the extraction of the oxidised ores of copper (carbonates and oxides) which necessarally occur nearest the surface; two distinct lodes have been worked, and on these have been sunk no less than eighteen shafts on what are known as the 'North and South lodes.' An adit has been driven from the side of the hill, and reaches a depth of 56 feet below the crown of the range. From this adit nearly up to the surface the carbonates have been removed by stoping.

"From one of the shafts, at a depth of 25 feet below the adit another adit has been driven northward. Good ore (copper glance, yielding in the company's furnaces 8 to 20 per cent. of copper) has been worked in this level, the lode here being from 4 ft. 6 in. to 5 feet wide. A specimen of this ore was assayed by Mr. Dixon, F.C.S., F.I.C., and yielded 27·9 per cent. copper.

"From this level a winze has been sunk to a depth of 27 feet, and from the bottom a drive has been worked northwards. Very good ore has been

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obtained here, viz., grey sulphide of copper, which in the Company's smelting works yielded 20 per cent. of copper; while Mr. Dixon found in a sample submitted to him 45·9 per cent. The lode in places is as much as 11 feet wide, though somewhat irregular, narrowing occasionally to 5 ft. 6 in.

"The South Shaft is vertical to a depth of 65 feet from the surface, and at this depth a drive has been put in east and west along the lode. A winze has been sunk 29 feet through yellow sulphide of copper and peacock ore, forming a fine lode, which increases rapidly in width as it descends.

"The South Shaft has been continued down on the underlie to a further depth of 140 feet, through the same ore, which at the bottom shows a splendid solid lode 11 ft. 6 in. in width, and without any gangue visible. The lode at this point dips at an angle of 63°. A sample of this ore was assayed by Mr. Dixon and yielded 16·7 per cent. of copper, though in the Company's smelting works it only averaged 9 per cent.

"The water of the mine holds a quantity of sulphate of copper in solution, which, while the shaft is being bailed, colours the creek a strong emerald green for a distance of more than a mile from the mine."

The quantity of copper in the Milburn Creek Mine water was found by Mr. W. A. Dixon to be 328·9 grains per gallon, equal to 4·698 lb. per 100 gallons. This water contained a considerable quantity of sulphate of iron in solution, but no free acid.

In the South Shaft the lode was found to improve in solidity and width as it descended, and at a depth of over 200 feet it was fully 11 ft. 6 in. from wall to wall.

In 1877 the mine changed hands under a Supreme Court decision. In 1878, it is stated that operations were continued during the year, and a considerable quantity of regulus was sent to Bowenfels to be refined. The Warden stated that, though badly worked, the mine was reported to be looking well.

In 1888 another lawsuit was pending. Nothing further appears in the records until 1888, when 14 tons of copper were despatched, work having been resumed by C. J. Campbell. In 1898 prospecting was being carried on along the line of strike outside the property.

When the first edition of this work was being printed, as briefly intimated, arrangements were being made for reopening Milburn Creek.

Under the title of the Milburn Copper Corporation an option was secured over the property in 1899; after unwatering and a little prospecting the option was forfeited. The mine being now again full of water, the owner—Mr. H. Haege—has placed at the Writer's disposal reports by Mr. F. Danvers Power (Lecturer in Mining, Sydney University) on the latest developments before closing down:—

Following are extracts therefrom:—

Report dated 9th October, 1900.

"Position of lode traceable by underground workings for a distance of 640 feet, and on the surface from the northern to southern boundary of M.C.P. 20.

"The average width of vein, which runs about north and south, is about 4 feet; but at the No. 1 and Water Shafts it widens to 12 feet.

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"The gossans left unworked have been leached out. The rich oxidised ores have been stoped out from the North Shaft to past the Crown Shaft.

"Where the stopes end south of the Crown Shaft, the ore appears to pitch underfoot to the south at an angle of 25 degrees, so that for the rest of the adit there is a blank, though the track of the lode has been followed to where it junctions with the east and west vein.

"Two leaders run into the main vein in this blank, and ore commences to make again where the second one meets it.

"Where the so-called east and west vein junctions with the main one, a large body of ore has been formed, and it is this that has been followed down in No. 1 Shaft. Except near the junction, the east and west vein does two appear to be of any value.

"The lower part of the North Shaft, and Pilkington's Shaft, being full of water, were not open to inspection.

"Most of the work has been concentrated in and about No. 1 Shaft, which has been converted into an underlay all the way.

"*Davies' Winze in No.* 1 *level, west drive.* Nos. 2, 3, and 4 are new levels driven from this North Shaft.

"No. 2, on west side of shaft, has followed some good ore in what I consider the east and west lode, until it made a bend where it appears to have been lost. The drive was curved round, and eventually cut the main lode.

"No. 3 was driven in country away from the lode, which is visible in face.

"No. 4 is near the bottom of the shaft, and is driven 24 feet in the lode; face 4½ feet wide without footwall.

"No. 1 Shaft has been deepened 40 feet, ore followed down all the way and still underfoot. The ore on the eastern side of shaft appears narrower than on western, due to the lode dipping south-west. Presumed footwall not definitely proved to be true wall.

"The other work consists of a foot or two driven on the east and west lode, east of the Eastern Shaft; also a few feet of cross-cutting on same level; and a short drive in the main lode below the adit level.

"Andrews' shaft, sunk 50 feet deeper—believed off the lode—not open to inspection owing to water.

"Pilkington's shaft, sunk 30 feet deeper on the lode, but in very poor stone, apparently above the shoot of ore.

"At time of inspection, face of every drive put in by the Corporation—excepting those hopelessly off the lode—showing good ore. Good ore also in the bottoms of the No. 1 Shaft, and Davies' and Pilkington's winzes."

Report dated 28th December, 1900.

"Lode originally approached in adit 380 feet long, and numerous shafts.

"The main shaft is sunk on an underlie in the wide portion on the junction of two veins, for a depth of 300 feet, being on good ore all the way.

"A sample taken right across the lode, where it is 12 feet wide, assayed 9·35 per cent. copper.

"A sample from the bottom of Davies' winze, also on the big ore body, and west of the main shaft, assayed—where it was 8 feet wide—7 per cent. copper.

"A sample from Pilkington's winze, east of the main shaft, assayed 8·95 per cent. copper.

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"There are four drives from the main shaft, and all the faces of them, except when off the lode, are on ore.

"A sample taken from No. 4 level at the bottom of the main shaft assayed 5·07 per cent. copper.

"A sample taken along No. 2 level, the good with the bad, assayed 4·29 per cent. copper.

"A general sample taken from a heap of about 400 tons at the mouth of the main shaft (extracted from the lower portions of the shaft and from the drives), all mixed together and averaged, assayed 5·46 per cent. copper.

"The ore has not been driven on for more than 24 feet on the south-west side of the main shaft.

"At the north end of the mine there has also been considerable work done, and more widened-out parts of the lode have been discovered and stoped.

"At this end it would appear as if the ore pitched to the north, and this may account for the ore in the lower part of Andrews' shaft (170 feet deep) being poor, as it is situated near to the crest of the hill, which appears to influence the pitch of the ore bodies.

"The North Shaft (140 feet) was full of water.

"*Conclusion.*—Ore still underfoot in deepest shaft (main), also to be seen in faces of all levels leading from it. Everything goes to show that there is ore below the adit level, where the shoot dips underfoot; for what would seem to be the cap of the same shoot is to be met in the face of No. 2 level.

"The ore is of a silicious nature, which lends itself to concentration by means of water.

"The mine water is in small quantity and easily kept down by kibble."

The Writer was informed by Mr. Woolcott, who had charge of the Corporation's operations, that the option was not exercised, because, in his opinion, the ore in sight was not sufficient to warrant payment of the stipulated sum required to secure the mine.

Sunny Corner Division.

Montana Silver and Copper Mine, Sunny Corner.—Re-opened by the Montana Copper Company in 1906. Winding plant erected. Rich leaders of copper ore reported in cutting down shaft. Prospecting continued during 1907. Main shaft sunk to 250 feet. Plant and buildings erected.

Bathurst Division.

Mountain Maid Lode, 3 miles south-west of Apsley Mine.—Two leases applied for by Marning and Hunt. Two shafts sunk 63 feet deep—20 feet apart—connected at 42. On small vein 4 inches to 6 inches wide of copper carbonates. An average sample of a few tons at grass yielded:—

No. 07-7944—Copper, 16·80 per cent.
Gold, a trace
Silver, 5 oz. 8 dwt. 21 grs. } per ton.

Rockley Division.

Mountain Run and Sugarloaf Mines, M.Ls. 2, 3, 9, 32, parish Ponsonby county Bathurst. About 10 miles from George's Plains Railway Station.

Two lodes, as named above, occur at this site in schist.

The Mountain Run, or eastern, was discovered about 1899; the western or Sugarloaf, about 1895.

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BATHURST MINING DISTRICT—*continued.*

The Mountain Run lode strikes N. 50° W. and dips S. 40° W. at 34°. Aided to sink from 10 to 75 feet (P.B. $\frac{1}{0}\frac{2}{1}\frac{5}{2}\frac{0}{0}$). Records to 62 feet show carbonates impregnating schist.

The Writer first examined this lode in 1899. Three shafts had then been sunk in it, 45, 50, and 125 feet; the average width of good ore being from 1 to 2 feet, though a greater width of very low grade occurred. About 340 tons of carbonate ore were reported to have been despatched to the Dapto Smelting Works by the Mining and Exploration Company then in occupation, for an average yield of 8 per cent. copper and 2 dwt. of gold per ton.

The leases were secured by R. S. Garbutt in October, 1905. The shafts were deepened in 1906 to 120 feet and 180 feet, and erection of a small circular water-jacket furnace (from Sunny Corner) begun; capacity about 25 tons per day, including fluxes. The main shaft cut into old workings at 170 feet on underlay.

The furnace started in March, 1907, and ran intermittently until October. About 1,400 tons smelted for the following consignment of matte:—

1,400 tons ore { 8 tons, 50 per cent. matte; 9 „ 43 „ „; 7½ „ 41 „ „; 34 „ 25 „ „; 20 „ 33 „ „ } Equalling about 1·8 per cent. of copper in the ore.

The presence of numerous "sows" down the slope from the furnace, evidences difficult or bad metallurgy, and may account for poor recovery.

A later campaign under the supervision of W. B. Dunstan reduced 260 tons for 35 tons of matte of 24·7 grade. Gossany ironstone for flux being procured from the Sugarloaf lode.

Recent examination of latest developments revealed about 3 ft. 6 in. of sulphides at a depth of 180 feet in the main shaft. A drive north 16 feet at this level showed about 2 feet of good grade sulphides on floor, with about 3 feet of very dredgy ore above. Driven 16 feet south—ore lens dipping underfoot.

An average sample of this ore yielded:—

No. 08-909—Copper, 7·32 per cent.; Gold, a trace; Silver, 1 oz. 1 dwt. 19 grs. } per ton.

Sugarloaf Lode.—On north-east slope of Sugarloaf Mountain. Strike N. and S., dip W. Shaft sunk in kindly ochreous gossan to 100 feet, thence into limestone, and again into ochreous gossan with a little carbonate of copper at 134 feet. A drive west through manganiferous ochre and occasional limestone, reached a belt of sulphide-impregnated rock, striking N. 15° W. and dipping S. 75° W., and several feet wide, bounded on west by chloritic schist, then crushed granulite.

From an enriched portion of this belt a sample was taken which yielded:—

No. 08-911—Copper, 5·20 per cent.; Gold, 1 dwt. 2 grs.; Silver, 9 dwt. 19 grs. } per ton.

About 5 chains west of Sugarloaf lode a massive lode of iron pyrites was cut in a shaft at 60 feet. At the 100-feet level it was driven on for 117 feet, where it had a thickness of 16 feet. Unfortunately it carries but a trace of copper.

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BATHURST MINING DISTRICT—*continued.*

An average sample yielding:—

No. 08-910—Copper, 0·72 per cent.
Gold, 1 dwt. 2 grs. } per ton.
Silver, 5 dwt. 10 grs. }

Though its composition makes it a useful flux for the dredgy Mountain Run ores, its poverty depreciates its usefulness.

The soft ochreous residual material found in considerable quantity in vugs in the Sugarloaf Mine—resulting from precipitation of insoluble oxides during process of dissolution of limestone—may prove of value as an ochre. Its composition is shown in the following analysis:—

No. 08-912—Total water	32·64
Manganese binoxide	29·21
Ferric oxide	8·60
Metallic copper	1·17
Gangue	8·87
Silver, 4 dwt. 8 grs. } per ton. Gold, a few grains }	

The other constituents present being alumina, lime, magnesia, a trace of zinc; also, a small quantity of sulphur trioxide and chlorine.

Orange Division.

Mount Bulga Copper Mine, on J. B. Lane's private land, parish Clinton, county Bathurst, 9 miles east of Orange.—Slate country. Strike of lode N.W., dip S.W. An impregnation—reported up to 25 feet in width. Depth of proving, 245 feet. Maximum length, 120 feet.

In 1901 the Mount Bulga Company erected machinery, deepened main shaft, and opened out at 200 feet (Ann. Rept., 1901, p. 54).

In 1902 a small blast furnace was delivered at the mine (*ibid.*, 1902, p. 49).

In 1903 the main shaft reached 245 feet, and the south drive 140 feet, A shaft was sunk 110 feet in M.L., in ironstone, carrying a little gold and silver (*ibid.*, 1903, p. 47).

In October, 1904, the mine was taken over by Messrs. Zobel and Gander, and unwatered to the 200-feet level (*ibid.*, 1904, p. 46).

The following analyses by D. C. Winterbottom show the composition of the Bulga ore:—

Character of Ore.	Copper, per cent.	Insoluble, per cent.	Iron, per cent.	Alumina, per cent.	Sulphur, per cent.
First Ore—Sold to smelters	7·2	23·0	32·6	7·5	Not determined.
Seconds—Average	3·1	36·0	23·0	8·4	.....
Carbonate ore from Whip Shaft	4·7	34·3	24·0	8·4	.....

The blast furnace ran for a short period, treating up to 40 tons of mixed firsts, seconds (sulphides), and carbonates. The slag, according to Mr. Winterbottom, had the following composition:—

Silica	39·0 per cent.
Alumina	18·0 „
Ferrous oxide	33·2 „
Lime	7·5 „
Copper	·5 „

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Limestone flux obtainable about 1 mile from the mine yielded on partial analysis:—

No. 08-588—Calcium carbonate	96·78	per cent.
Magnesium carbonate	1·55	„
Ferric oxide and alumina...	·46	„
Gangue	1·12	„
	99·91	„

Mr. M. Zobel states that the mine was opened about 1893 by a prospector named Phœbe. Some small parcels of carbonates were disposed of for yields up to 15 per cent. During 1907 some 3,000 tons of sulphides yielded an average of 6½ per cent. at public smelters. Progress has been delayed by litigation, and work is now suspended.

Tuena Division.

Mount Costigan.—Discovered by J. Maguire in the early 80's. Copper sulphides made their appearance below water-level, in a refractory combination with sulphides of lead, zinc, and iron, very similar to the ores in the lower levels of the Lewis Ponds and Sunny Corner Silver Mines.

Mount Costigan was worked as a silver-lead proposition until 1889. A depth of about 200 feet was reached before the mining and smelting plant was dismantled in the above year.

Re-opened in 1906, by the Mount Costigan and Cordillera Company, for copper and other ores below water-level.

In 1907 it was reported that 50 tons of ore had been despatched for shipment to Europe, averaging by bulk assay over 12 per cent. of copper, from a lode 4 feet wide. Assays have also shown gold 2 dwt. 4 grs., and silver 12 to 20 oz. per ton.

Orange Division.

Mount Fraser Copper Mine, Springfield Estate, near Icely.—This mine was re-opened in 1907, 50 tons of ore valued at £600 being raised. Shaft, 100 feet, driven at that level 120 feet north and 80 feet south. Lode varied in width, 8 inches to 2 feet.

Mount Lindsay Copper Mine, M.Ls. 55 and 56, parish March, county Wellington. Rosedale, near Orange.—Strike N. 25° W., dip 1 in 5 in slate and quartz-felsite. Opened by cross-cut tunnel. Lode 2 to 4 feet wide; driven on for about 30 feet.

The ore is of refractory nature, as disclosed in the following partial analysis:—

No. 08-565—Copper	4·40	per cent.
Lead	4·65	„
Zinc	17·63	„
Gold, a trace Silver, 20 oz. 9 dwt. 10 grs.		per ton.

Fifty tons sent to Blayney Smelting Works and 10 to Waratah averaged 4½ per cent. of copper; its composition, however, prevented further sale, and caused the closing of the mine.

Near Mount Lindsay the Federal Syndicate is reported to have sunk 140 feet in similar lodestuff—none of which was disposed of.

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BATHURST MINING DISTRICT—*continued.*

Mount McDonald Division.

Mount McDonald.—About half a mile north of Mount McDonald, and the same distance south of Milburn Creek Copper Mine, in the parish of Dunleary, county of Bathurst.

Inspector D. Milne (P.B. $\frac{1420}{1899}$) states that the country consists of slate with bunches of quartz, gossan, and blue and green carbonates; strike north and south. Apparently a continuation of the Milburn Creek lode. The only provings at the time of inspection were several shallow openings along the outcrop. Aid granted to sink 60 feet, and to drive 80 feet on the course of the lode. A sample from the outcrop, $\frac{1402}{98}$, consisting of ferruginous blue and green carbonates, yielded 40·1 per cent. of copper, and 8 oz. 18 dwt. 14 grs. of silver per ton.

On the southern strike of the Milburn Creek Lode, shafts were sunk some eighteen years ago to depths of about 70 feet, and some rich ore is reported to have been raised.

Bathurst Division.

Mount Morris Copper Lode (? Mount Nome), M.L. 37, parish Ponsonby, county Bathurst, about 2 miles easterly from Apsley Copper Mine.—Carbonate and sulphide ore in schist:—

Sample 07-2638—Copper, 26·70 per cent.
Gold, a trace
Silver, 1 oz. 8 dwt. 7 grs. } per ton.

Orange Division.

Mount Ragan (or Regan), portion 6, parish Worcester, county Bathurst, near Lewis Ponds, about half east of Britannia Mine.—Discovered by Hayward Brothers, about 1878.

Aided in 1899 to sink from 55 feet to 145 feet, and to drive 50 feet (P.B. $\frac{1305}{99}$). Progress:—At 65 feet a little black ore showing; 9-inch vein of black ore at 91 feet; 6-inch vein at 116 feet; small vein continuing down to 138 feet (last measurement).

Strike N. 30° W., dip N. 60 E. at 145°, in slate and schist. Depth of proving, 145 feet. Length proved by four shafts about 180 feet. Vein narrow, averaging about 7 inches; rich yellow sulphide at bottom. Stoped up from 60-feet level.

Samples of mixed sulphides in mica schist, and of better grade ore, gave the following returns:—

Assay No.	Description.	Copper.	Zinc.	Gold.	Silver.
					oz. dwt. grs.
07-5080	Mixed sulphides	3·92	26·76	A trace	1 1 19 per ton.
07-5714	First-grade sulphides...	13·92	.....	,,	2 15 13 ,,

The output from July, 1906, to about July, 1907, amounted to 38 tons 12 cwt. 2 qrs., averaging 22·7 per cent. of copper, the high price of copper then prevailing enabling this small vein to be profitably worked.

The South Block adjoins M.L. 6 on the south. Here two shafts have been sunk on a parallel vein on the south-west to depths of 45 feet and 75 feet.

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Strike N.W. Width about 6 inches. Same character as Mount Ragan ore. Lost ore at 47 feet; drove 37 feet S.E. and sunk winze 28 feet. About 3 inches of rich sulphide at bottom of winze. Seventy-eight bags sent to Newcastle Copper Works yielded 19 to 20 per cent. of copper.

North Block.—Adjoining M.L. 6 on north. Strike N. 30 W., dip N. 60° E. (Mount Ragan line). Channel about 2 feet wide. Carbonates and oxides to about 35 feet. To this depth 250 bags of ore were extracted from a stope about 50 feet long.

In the lower levels of the 70 feet shaft zinc-blende largely predominates, as will be seen by the following assay:—

No. 08–577—Copper ..... 2·02 per cent.
Zinc ..... 32·29 „
Gold, a trace
Silver, 13 dwt. 1 gr. } per ton.

At the extreme north end of the original Mount Ragan workings, Dwyer and party sank 78 feet and drove 35 feet. Quartz on hanging wall side at 27 feet, carrying a little black ore in vugs. Channel very narrow at bottom of shaft. Ore dredgy, thinned to mere strings at south end. The composition of the ore is revealed in the accompanying assay:—

No. 08–576—Copper ..... 4·77 per cent.
Zinc ..... 11·97 „
Gold, a trace
Silver, 1 oz. 8 dwt. 7 grs. } per ton.

Mount Shorter.—P.G.L. 6, parish March, county Wellington. Rosedale, near Orange.—Worked superficially for gold, a little copper ore making for a width of 3 to 12 inches in shallow shaft. Strike N. 65 W., dip S. 25 W. at 1 in 5.

An average sample of the copper ore yielded:—

No. 08–566—Copper, 18·80 per cent.
Gold, a trace
Silver, 2 oz. 14 dwt. 10 grs. } per ton.

Sunny Corner Division.

Nevada Silver and Copper Mine, Sunny Corner.—Taken possession of by Sunny Corner S.M. Co. in 1901; unwatered, re-timbered, and connected by tram with smelting works. 300 tons smelted with Sunny Corner Mine ores. (Ann. Rept., 1901, p. 54.)

Blayney Division.

Newbridge District, 10 miles S.E., parish Bringellat, county Bathurst.—Inspector G. Smith reported copper pyrites striking N. and S. and dipping E., in chlorite schist. Shaft, 60 feet.

Rockley Division.

North Essington Mine, Native Dog Creek, parish Baring, county Westmoreland. (*See* Essington Mine.)—Inspector B. Sawyer reported (P.B. $\frac{2}{0}\frac{1}{4}\frac{8}{}\frac{3}{}$) pyritous slates and schist. Aided to sink to 80 feet. At 37 feet fair percentage of copper reported. Bulk sample at Lithgow yielded 9½ per cent. of copper.

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BATHURST MINING DISTRICT—*continued.*

Orange Division.

O'D Mine, parish Calvert, county Bathurst, 9 miles north of Millthorpe.—Worked for gold about 1880. Inspector Smith reported copper pyrites in igneous rock, strike N.W., dip S.W. Thickness, 3 feet. Maximum depth of proving, 69 feet; length, 30 feet. Outcrop traceable for about 400 yards. No records of early workings. Six tons raised, estimated to contain 8 to 10 per cent. of copper.

Ophir Copper Mine, south-east of Lewis Ponds, parish Byng, county Bathurst.—In 1852 a company was formed to work this mine, and a Bill to incorporate was presented to Parliament in 1853. Ores from the mine were exhibited at the Paris Exhibition of 1855. No particulars are available of the early operations. In *Mineral Statistics of New South Wales*, 1875, p. 91, the Company is referred to as working a lode at Brown's Creek having an average thickness of 2 feet; a north and south strike, and an easterly dip of 1 in 6; proved to 150 feet. Ores consisted of carbonates, oxides, and sulphides (containing gold) in a quartz matrix. Two hundred tons had yielded 30 tons of copper. Twenty men were employed. This lode was afterwards worked by the Great Western Copper Mining Company, which see.

Re-opened by the Ophir Gold and Copper Mining Company under agreement with owners during 1906–7. Cleaned out a tunnel for over 600 feet; cleaned out and re-timbered old shaft to 120 feet; sank a new shaft 85 feet, all on the same line.

The tunnel section reported from 2 to 12 feet wide. A big deposit of low grade material reported at bottom of 120 feet shaft 8 chains further south.

The 85-feet shaft on the south-eastern strike, 300 feet south of the latter, is also in ore of low grade.

The quality of the ore raised from these recent workings is very low, as will be seen in the assays of average samples:—

Assay No.	Description.	Copper, per cent.	Gold, per ton.	Silver, per ton.
				dwt. gr.
07-571	Quartz and pyrites from tunnel	0·25	a trace.	3 6
07-567	Quartz and pyrites from bottom of 120 feet shaft.	1·00	,,	15 6
07-568	Carbonates and sulphides from 85 feet shaft.	1·77	,,	4 8

The early workings along the Ophir line of lode have been extensive, but evidently shallow, and confined to the oxidised and enriched zones; the sulphides evidently, as shown above, are very low grade.

Tuena Division.

Peelwood Copper Mine, 10 miles from Tuena.—Mr. Warden T. A. Smith states that this mine was discovered by W. Montague and W. Ford about 1874. They sold to the Peelwood Mining Company, who put up smelters and worked the mine for about four years, reaching a depth of about 400 feet.

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The first official record of this mine is contained in *Mineral Statistics*, 1875, p. 91. The lode is herein stated to have been 4 feet in thickness, striking north and south, and dipping east at 15°. The footwall country is schist, and the hanging wall soft slate. Silver and lead ores were associated with the copper ores. A shaft had been sunk 384 feet, and about 1,900 tons of ore raised to that date, 1,100 of which had been smelted for an average yield of 12½ per cent. of copper. Four reverberatory furnaces were in use.

During 1875 322 tons of ore were raised, which yielded 32 tons 4 cwt. of copper, valued at £3,220.

In 1876, the Mine Manager (Mr. Williams) supplied the local Warden with the following particulars:—"During the past year the mine has been sunk 120 feet diagonally [On the underlay of the lode.—J.E.C.], making a total depth of 420 feet from the surface. Bearing of lode north and south underlying eastward at an angle of 45°. The lode contains copper, lead, zinc, and silver, and varies in thickness from 1 foot to 20 feet. Throughout the mine there is abundance of lead ore, containing a good deal of silver, which is smelted with the copper ore, thus rendering the produce in regulus, which contains from 40 to 50 per cent. of copper, 30 to 40 per cent. of lead, and from 100 to 130 oz. of silver per ton. The mine, during 1876, has produced in regulus and lead 300 to 350 tons.

"The working plant consists of two large portable engines, with crushing and dressing machinery, four reverberatory furnaces, and a calciner. The latter is used for desulphurising and expelling fumes of zinc, preparatory to smelting operations, otherwise there would be great difficulty in obtaining separation of the slags and metals."

The progress of the mine from 1876 is briefly recorded in the following extracts from the Annual Reports of the Department of Mines:—

In 1877 mine reported steadily at work raising and smelting ores, but returns are not given.

1879 mine shut down, causing a great blow to the district; subsequently re-started by local men.

1880.—Mine worked regularly. 136 tons of copper produced, valued at £5,444.

1881.—Peelwood Tributers reported steadily at work, but no returns given.

1882.—950 tons of ore raised, valued at £2,910. Mine closed before the end of the year.

1883–4–5.—No records. Mine apparently closed.

1886.—Mine changed hands after being idle for several years.

1887.—No records.

1888.—Twenty-four men employed.

From this date no further work appears to have been carried on. The sulphide ores at bottom are undoubtedly very zinciferous, the proportion being about—copper, 4 per cent.; zinc, 25 per cent. A water-jacket furnace was erected in 1888, during the silver boom.

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BATHURST MINING DISTRICT—*continued*.

It is interesting to note that the rare elements, "gallium" and "indium," have been detected in the blende (zinc sulphide) of Peelwood, by Mr. J. B. Kirkland, F.C.S. (Assistant Lecturer and Demonstrator of Chemistry, University of Melbourne), who made the following analysis of the Peelwood ore:—

Silica	6·05	
Lead	16·71	containing 11 to 12 oz. of silver per ton.
Iron	11·06	
Copper	5·00	
Zinc	29·77	
Sulphur	29·21	
Loss, &c.	2·30	
	100·00[1]	

The Peelwood mine and smelting plant were dismantled about 1889. The ground is held as a mineral conditional purchase.

Rockley Division.

Phœnix, late Larry's Hill Copper Mine, parish Jocelyn, county Westmoreland.—The Larry's Hill lode was opened about 1895, under the name of the Phœnix. A shaft was sunk 90 feet, and several parcels of dressed ore were sent to Lloyd's Smelting Works, Lithgow. Later, about 150 tons were forwarded to Lithgow, and there reduced to matte in a small furnace, by one of the parties interested, in which state it was shipped to London. The quantity and grade are unknown, but the transaction was financially unsuccessful.

The Larry's Hill Syndicate took possession about 1897, and began a new shaft about 40 feet north from the first. Later they received aid from the Prospecting Vote to continue to the 150-feet level. At the date of inspection, 14th November, 1898, a depth of 100 feet had been reached and a level driven 30 feet south. At the 50-feet level the shafts are connected.

The geological formations are quartz porphyry passing on the west, through much crushed schistose porphyry, into talcose schist in which the lode occurs striking nearly north and south. Its thickness varies from 1 ft. 6 in. to 2 ft. 6 in.

The oxidised zone extends to a depth of 50 feet, at which level the sulphides appear. The oxidised ores consist of kindly, and silicious gossans, with carbonates of copper and lead, thin streaks of grey sulphide, and a little barytes.

The composition of this class of ore may be judged from the following partial analysis:—

No. $\frac{1,2,3}{5,6,7}$, gossan ores from above 50-feet level:—

Copper	6·74 per cent.
Lead	12·10 „
Zinc	4·58 „
Iron	23·78 „
Silica	22·89 „
Silver, 4 oz. 12 dwt. 13 grs. per ton.	
Gold, a trace (under 10 grs. per ton).	

[1] Austr. Assoc. Adv. Science, 1892, IV, pp. 206-7.

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BATHURST MINING DISTRICT—*continued.*

The composition of the sulphides is illustrated in the following table of partial analyses, selected to represent the highest and lowest grades, and an average of the two, the grade being determined by the amounts of copper and zinc present:—

Assay Nos.	No. 495, "Highest Grade."	No. 494, "Lowest Grade."	No. 493, "Average."	Average of 494 and 495.	"Mixed Ores"* from the Rammelsberg, Germany (for comparison).
	per cent.	per cent.	per cent.	per cent.	
Copper	8·45	5·80	6·54	7·12	4·78
Zinc	14·96	30·73	16·49	22·84	21·25.
Lead	3·86	7·37	4·76	5·61	8·84
Iron	22·92	12·06	17·79	17·49	12·54
Silica	16·57	10·95	21·12	13·76	19·19 (residue probably silica.)
		Per ton. oz. dwt. gr.	Per ton. oz. dwt. gr.		
Silver	Trace.	5 19 18	10 5 19	.....	.....
Gold	Trace.	Trace.	Trace.	.....	.....
Sulphur	.....	.....	.....	.....	24·11

* NOTE.—This class of ore (closely approaching the Larry's Hill ore) is subject to special treatment at Oker, on account of the high percentages of zinc and lead. Several special operations are necessary for recovery of the economic metals. The composition of the ore is iron and copper pyrites, zinc-blende galena, barytes, &c. (C. Schnabel, Handbook der Metallhüttenkunde. Translated by H. Louis. Vol. I, pp. 155-6.)

These analyses reveal a refractory smelting mixture, owing to the high percentages of zinc and lead. Repeated heap-roasting with carbonaceous fuel would render this class of ore more amenable to furnace treatment, by eliminating a portion of the zinc and lead contents, but judicious blending with less refractory ores would be most advisable.

Five tons of the better grade of this class of ore were treated at the Cobar Syndicate Smelting Works, Lithgow, for a return of 7 per cent. of copper.

Progress.

In 1901 the main shaft reached 135 feet. Reverberatory furnace erected.

About 300 tons of ore were raised during 1902. Main shaft, 183 feet.

Smelting commenced in September, 1904, the mine being idle for the ensuing eight months. Value of matte produced, £920.

Worked intermittently during 1905. Output, 650 tons of ore. Value of copper contents, £1,707. Closed in 1906.

During 1907 prospecting work actively engaged in; main shaft being deepened 150 feet; furnace rebuilt.

One thousand three hundred and fifty tons of ore smelted for 108 tons of 42 per cent. matte, valued approximately at £5,000. Smelting ceased in September, grade of ore being found too low for remunerative smelting when value of copper fell. Aid granted for prospecting lower levels in 1908.

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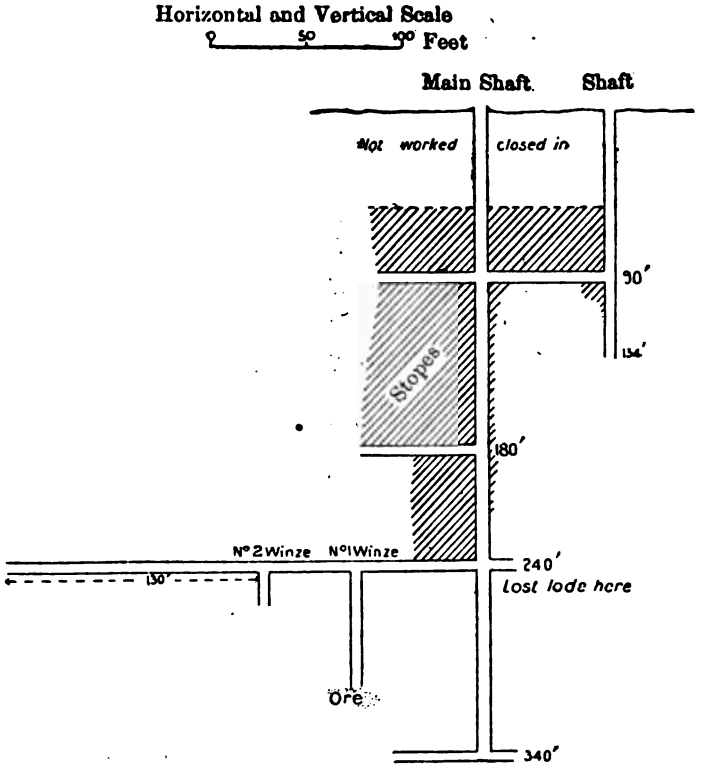
BATHURST MINING DISTRICT—*continued.*

Position early in 1908.—The extent of development is shown in the longitudinal section below. Present operations under aid being a south drive from 340-feet level to intersect the shoot of ore cut in No. 1 winze from 240-feet level.



The composition of the Phœnix ore is shown in the following partial analysis of mixed sulphides from No. 1 winze (300 feet), and from the 140-feet level:—

No. 08–917—Copper	4·30	per cent.
Zinc	11·35	„
Iron	20·16	„
Sulphur	27·72	„
Silica	26·25	„
Gold, a trace Silver, 8 oz. 3 dwt. 8 grs.	per ton.	

A sample from the 140-feet level, tested separately, yielded:—

No. 08–916—Copper, 4·70 per cent.	
Gold, 2 dwt. 4 grs. Silver, 9 oz. 7 dwt. 7 grs.	per ton.

The reverberatory furnace—17 ft. x 11 ft. 6 in.—has a capacity of about 60 tons per week. Lithgow (Sandford) fire-brick being used in its construction, and Lithgow sand for bottoms.

Ironstone flux has hitherto been mined from the cap of a parallel lode on the west.

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BATHURST MINING DISTRICT—*continued*.

Orange Division.

Pride of the Hills Mine, P.G.L. 1, parish March, county Wellington. Rosedale, near Orange.—Worked for gold. A little rich fahl ore at 180-feet level, width 1 to 8 inches, assaying:—

Assay No.	Description.	Copper, per cent.	Zinc, per cent.	Lead, per cent.	Gold, per ton.	Silver, per ton.
						oz. dwt. gr.
08–563...	Fahl ore, 180 feet level (1–8 in.)...	5·35	9·80	5·50	a trace.	194 2 22
08–564...	Lead-zinc ore, 180 feet level (3 feet wide).	0·50	23·55	13·40	,,	18 12 9

Strike of lode N. 25 W.; dip, S. 65° W. at 1 in 5. Country, slate and crushed quartz felsite. Stoped about 130 feet to north-west at 150-feet level; and for 70 feet at 80-feet. Depth of shaft, 200 feet.

Rockley Division.

Prosper Mine, parish Baring, county Westmoreland, near Essington.—Old workings re-opened in 1907. New shaft 60 feet on underlay in carbonate ore—width, 6 in. to 2 ft. 6 in. Strike N. 10° W.; dip, west. Two lodes about 500 feet apart. The western was opened some years ago, revealing low-grade silicious ore—partly chalcedonic; sulphides showing leanly.

The oxidised ores only extracted in the main or east workings; about 60 tons despatched for a reported yield of 8 to 10 per cent. copper. This lode dips at about 30 degrees only. The deepest workings being 60 feet. Stopes extend for a length of over 100 feet at the 40-feet level, and up to surface. A few feet of stoping only at 60 feet. In June, 1908, brick-making was in progress in connection with erection of a reverberatory furnace, which had been decided upon.

Blayney Division.

Quigley's Hill Copper Mine, about 5 miles south of Blayney.—A thin vein of copper pyrites was followed down in this mine for about 140 feet in sedimentary rocks—slates and sandstones. The channel rock consists of greasy jointed and cleaved slates. Inspector D. Milne states that at 100 feet the vein was about 6 inches thick. Nine tons of ore sent to Lithgow for trial yielded 9 per cent. of copper. This amount, judging from the tip, is all the ore raised during operations.

Orange Division.

Ratscastle Lode, portion 15, parish Byng, county Bathurst, on W. Hawkes' estate, near Byng.—Opened some years ago; 20 tons sent away. Re-opened in 1907 by Thomas and party; despatched 12 tons of seconds from old shaft for a return of 7 per cent. of copper. Country chlorite schist. Lodestuff silicious.

Bathurst Division.

Red Hill Mine, M.L. 31, parish Ponsonby, county Bathurst.—Prospected many years ago.

In 1901, 250 tons of ore were raised, 53 of which were disposed of (Ann. Rept., 1901, p. 54).

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Sulphides reported at 70 feet. Ore at grass consists of hornblende schist with cubical pyrites and some chalcopyrite. Limestone closely adjacent. No defined walls. Strike of sulphide bunch N. 25° W. Width 7 to 8 feet.

Ore raised in 1903 not rich enough to despatch.

Reopened in 1906 by J. Osborne—a little carbonate ore showing in open cut. Sinking on underlay.

Work resumed towards end of 1907.

Blayney Division.

Rise and Shine Mine, Brown's Creek, 9 miles S.E. of Newbridge Railway Station, portion 35, parish Ponsonby, county Bathurst.—Strike, N. and S.; dip, E. in schist; width, 5 feet to 8 feet; maximum length of proving, 200 feet; depth, 80 feet. Ore sulphides and carbonates carrying gold and silver.

Inspector D. Milne reported (P.B. $\frac{84}{50}$) a rich pipe of copper ore; 60 to 80 tons good ore obtained.

Rockley Division.

Rockley District. (*See* Cow Flat, Apsley, Belmore, Summerhill, and Mountain Run Copper Mines).—Copper ores occur in numerous places in this district. Besides those abovementioned, the following have been reported:—

Back Creek.—Sample assayed $\frac{20}{50}\frac{2}{50}$ and $\frac{14}{50}\frac{8}{50}$ yielded 30·16 and 11·86 per cent. of copper.

Rockley, 5 miles east.—Sample $\frac{20}{50}\frac{4}{50}$, copper, 21·05 per cent. ($\frac{15}{50}\frac{1}{50}$ and $\frac{15}{50}\frac{2}{50}$); copper, 16 to 17·67 per cent.

Rockley, 8 miles north-west.—Sample $\frac{2}{50}\frac{6}{50}$, copper, 32·52 per cent.; silver, 2 oz. 3 dwt. per ton.

About 7 miles north-west of Rockley, and 1½ miles west from the Rockley Bathurst Road, parish Ponsonby, county Bathurst.—Inspector Milne reported (P.B. $\frac{15}{50}\frac{2}{50}$) that Byron and party were prospecting for copper in schist country. Shaft 110 feet, stoped at south end. Some years back a bunch of fair ore was worked from surface to the 110-feet level where sulphides were met. The oxidised ores were stoped out for a length of about 60 feet, pinching at each end of the stope. At this stage the mine was abandoned. The channel is described as well-defined, and the outcrop strong. From the shaft 6 tons of ore yielded 7·5 per cent. of copper. Aid granted to continue prospecting.

Rockley, 13 miles from, on south side of O'Connell to Essington Road, parish Baring, county Westmoreland.—Inspector D. Milne reported (P.B. $\frac{15}{50}\frac{12}{50}$) a quartz reef with splashes of yellow ore in schist. Formation 3 to 4 feet wide. Aided to sink from 30 to 100 feet.

Rockley Farm, about 2½ miles east of Rockley.—Inspector G. Smith reported (P.B. $\frac{15}{50}\frac{12}{50}$) quartz vein in porphyry (?), carrying small bunches of copper and iron pyrites with blende, &c. Shaft, 23 feet. Aided to sink to 50 feet.

Inspector Milne reported (P.B. $\frac{15}{50}\frac{13}{50}$) copper-stained country about half a mile south of the above site; also about 100 yards north, but no sign of lode.

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On south-east side of O'Connell-Essington Road, between Captain King's Creek and Brisbane Valley; an old mine reopened in 1907 by new shaft in north end of outcrop, by Kennedy and party. At south end old workings reopened under aid.

Rockley.—At junction of Back and Davy's Creeks a small vein of copper carbonate and oxide was opened for a few feet about 1902; and reopened by Ryan and Hanson towards end of 1907. Copper stains for a width of 2 or 3 feet; best indications about 15 inches wide.

About 1¼ miles south-easterly from Rockley green carbonate of copper showing slightly in quartz, opened for about 15 feet.

North end of Dog Rocks on the Brownlow estate, carbonates and sulphides occur; width not defined; opened in 1907 for about 13 feet.

In portion 153, parish Rockley, county Georgiana, copper vein opened by Cock and party some years ago. Shaft sunk to 84 feet under aid. Abandoned.

Ranger's Mine, portion 43, parish Rockley, county Georgiana, about 2 miles east of Rockley on Pepper's Creek. Shaft, 48 feet.

An irregular vein of copper ore (yellow sulphide) 2 or 3 inches thick in massive quartz, traversing a belt of hard quartzite. Several other similar but thinner veins occur in the rocky creek bed in a width of several chains.

About 8 chains south-easterly another shaft has been sunk a few feet, showing splashes of copper sulphide in country—no defined lode channel. Massive quartz forms a bluff outcrop between the shafts. Strike of veins about N. 50° W. Abandoned.

"*Shepherd's*" *Mine*, M.Ls. 33, 34, parish Ponsonby, county Bathurst, near Mountain Run Mine.—Originally opened by Thomas Quin. Country, crushed quartz felsite and chlorite schist.

Good carbonate ore reported to have been taken out in Cow Flat Smelting days, from an open trench or cut 30 feet deep. The mine was reopened about 1895 by Amos and Shannon, in another shaft a little further south.

Shaft sunk in 1907, 85 feet, and driven 15 feet north at 65 feet, on a vein about 1 ft. 3 in., which split into strings in hard country at bottom. Ore consists of carbonates, oxides, and sulphides associated with quartz.

In the same leases nearer Mountain Run, two other shafts have been sunk, revealing stains of carbonate in schist, and further east, in slate, neither of importance.

About half a mile east of the Shepherd Mine a cross lode was sunk on by J. Hunt about 1906, who cleaned out old shafts down about 70 feet, and drove west on a narrow vein from 9 to 10 inches in width carrying carbonates and sulphides—a few tons raised, none sent away.

Rockley, Brown's Creek, near Back Creek, Caloola.—Inspector H. Hooke reported (P.B. $^{2}\frac{8}{5}\frac{8}{5}^{0}$): Copper-bearing veins in chlorite schist (carbonates and sulphides) in bed of creek. Aided to sink 150 feet, and cross-cut 60 feet.

Lode opened by four shafts ranging in depth from 30 to 110 feet. 110-feet shaft driven west 40 feet. Water struck at 90 feet. Lode pinched out at 60 feet.

Further aid ($^{1}\frac{7}{0}\frac{1}{2}^{0}$) to drive 100 feet north and south on lode at 90 feet. No marked improvement.

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BATHURST MINING DISTRICT—*continued.*

Mount McDonald Division.

Silver City Lode, parish Dunleary, county Bathurst.—J. Holden raised 24 tons of ore valued at £156 (Ann. Rept., 1903, p. 47).

Orange Division.

Slattery's Creek, in J. Kelly's Pastoral Lease.—Inspector H. Hooke reported (P.B. $\frac{8}{9}\frac{1}{2}\frac{2}{9}\frac{1}{7}$): Diorite dyke traversed by veins of copper pyrites. Aided to tunnel 100 feet and cross-cut 20 feet. At 62 feet, a little copper showing between good walls; at 98 feet, a little copper, gold and silver; at 101 feet, no improvement.

Slattery's Creek, 3 miles south of Forest Reefs Post Office.—Inspector J. James reported (P.B. $\frac{1}{0}\frac{4}{6}\frac{0}{8}\frac{8}{4}$): A copper vein in slate showing about 8 inches thick at bottom of 45-feet shaft. Aided to sink to 100 feet. At 68 feet a little good ore. No further report.

Reported in March 1907, that Mills and party were working a small vein of copper ore; the last consignment realised £1 per bag.

Burraga Division.

Sprague's Mine (or Mount Burraga) M.L. 4, Parish Jeremy, County Westmoreland. About 1 mile east of Lloyd Copper Mine, Burraga.—Inspector H. Hooke reported (14/7/01): Strike, N. and S. Proving—depth, 87 feet; length, 340 feet. Being reopened by new shaft.

In 1902 was worked to end of April; shaft deepened to 162 feet. Driven 82 feet at 140-feet level. Lode cut in drive assayed 3½ per cent. (Ann. Rept., 1902, p. 49).

Examined by Inspector D. Milne (P.B. $\frac{8}{0}\frac{6}{7}\frac{8}{8}$). Aided to sink the 70-feet underlay shaft a further 50 feet, and to drive 50 feet. Pyritic lode underlaying 1 in 5 to the west. Varied in width from a few inches to 4 feet. Contains fair grade yellow ore in parts.

At 80 feet pinched to a thread, widening again at 90 feet. Good patches of ore met in shaft and cross-cut, but always cut out in a few feet.

Rockley Division.

South Wiseman's Creek Copper Mine, on the south bank of Wiseman's Creek, on the same lode as the Wiseman's Creek Mine.—The earliest record of this mine is contained in *Mineral Statistics*, 1875, p. 92, in which the depth of proving is given at 120 feet. Assays returned 9 to 20 per cent. of copper, and 9 to 20 per cent. of lead, and traces of gold and silver. Two hundred tons of ore had been raised, and sold at £6 10s. per ton.

In 1876 and 1877 the mine was idle. In the latter year it was visited by the late Government Geologist, Mr. C. S. Wilkinson, who stated that it was apparently on the same line of fault as that in which the Wiseman's Creek Mine is situated. During $\frac{1}{D}\frac{8}{0}\frac{7}{7}\frac{8}{1}$ a little work was done near the surface for carbonate ores. In $\frac{1}{D}\frac{9}{0}\frac{0}{1}\frac{4}{1}$ the presence of silver in some quantity having been detected in the lodes of Wiseman's Creek, considerable attention was directed to them. A tunnel near the creek level was at this time started in the South Mine.

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Attention was directed to the locality in 1899, chiefly owing to the substantial rise in the value of copper, and a little work was done in cleaning out and repairing the main shaft and tunnel. The Wiseman's Creek ores are unfortunately contaminated with zinc sulphide, which renders them refractory.

Blayney Division.

Sugarloaf Copper Mine (Wright and Osborne's), about 2 miles south of Blayney.—Discovered in 1896. Outcrop consists of magnetic and brown iron ore in andesite. The iron ore is of excellent quality. Under the oxidised cap, massive pyrrhotite (magnetic pyrites) occur, containing a little copper pyrites. The leaching out of the copper from the outcrop has been very thorough, and nearly as complete in the underlying magnetic pyrites. An assay of a selected sample of the latter yielded only 0·45 per cent. of copper whilst below this level a mixed sample of pyrrhotite and chalcopyrite yielded 12·68 per cent.

As work had ceased when the Writer visited this mine in 1898, an inspection of the lower levels was not feasible. It is reported by Mr. J. Russell, of Blayney, that the two shafts are 75 and 105 feet respectively. In the former a cross-cut has been extended 9 feet, and in the latter (at 50 feet level) 53 feet in lode-stuff. The ore consists of a mixture of copper and magnetic-iron pyrites, averaging about 7 per cent. copper. At the bottom of the 105-feet shaft a cross-cut has been driven 13 feet, also in lode-stuff. Fifteen tons 18 cwt. of ore from this mine, treated at the English and Australian Co.'s works, Waratah, yielded 5¾ per cent. of copper; gold, about 3 dwt.; and silver, 3 oz. per ton.

The Blayney Mining and Smelting Company prospected the old workings in 1907 without discovering payable ore. The lode made largely into pyrite, partly magnetic. The company sank to 165 feet, and cross-cut 100 feet.

Canowindra Division.

Sugarloaf, parish Malongulli, county Bathurst, near the Belubula River, on Cliefden Station.—The late Mr. W. M. Rothery, owner of this station, many years ago discovered a small, loose specimen of native copper close by a small creek. Later the lode was discovered. About three years ago arrangements to test it were made with the late Marmaduke Constable, and a shallow shaft and open-cut were sunk. Near the surface some fine specimens of native copper and cuprite were revealed by a blast. The country consists of highly-altered sedimentary rocks, close to the junction of hornblende porphyry. Superficial copper stainings marked the rock raised during operations; but nothing payable was discovered so far as these proceeded. A rough, rocky outcrop occurs, extending southerly, in which ferruginous bunches occur with stains of copper carbonates. This outcrop could be well tested by tunnel.

Carcoar Division.

Summer's Copper Mine, 3 miles south from Carcoar on the Coomba Road, on the west side of Coombing Creek, parish Summers, county Bathurst.—Inspector D. Milne, in October, 1896 (P.B. $\frac{1}{8}\frac{9}{96}$), reported that the lode has a thickness of about 3 feet, with a gossan outcrop. Strike, north-

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west and south-east; dip, nearly vertical. The ores consist of carbonates, black and yellow ore, but rather dredgy. At 105 feet the lode appeared to be making stronger. Aid granted to continue prospecting. At 155 feet the thickness was 3 to 4 feet. Five tons sent to a smelting works yielded 11½ per cent. of copper.

Rockley Division.

Summerhill Copper Mine, parish Rockley, county Georgiana.—One of the earliest copper-mines opened in the Colony. According to Mr. James Ranken, of Bathurst, work was in progress here as early as 1847. In the following year a company was formed in Bathurst to work this property. An extract from the prospectus of the Bathurst Copper-mining Company, published in the *Bathurst Advocate*, of the 30th December, 1848, is embodied in the introductory portion of this work.

In April, 1851, Mr. S. Stutchbury examined the mine, and reported as follows:—"The rocks or strata in which the mining is carried on are for the most part mica and grindstone slates. The strike or level line is west of south and east of north. The workings consist of three shafts—the Gilmandyke, Clymo's, and the present working shaft. The sinkings are on two lodes, parallel to each other. The ores which form the bulk for smelting are pyritic, viz., yellow sulphuret of copper, arsenical sulphuret of copper, and domeykite (?) of Waidinger. There are other varieties in small quantities. On the spoil heaps may be seen some very beautiful sulphates, formed by decomposition of the sulphides by exposure to the atmosphere At the bank of the eastern shaft there is a large heap of ore which, from its appearance, I take to be domeykite, or arsenical sulphuret of copper—a very rich ore. This has been thrown out as waste, under the impression that it was iron pyrites—'mundic.' There is also much valuable ore on the spoil-heaps and underground in one of the vugs. The experiment of smelting with green timber is in a fair way of being successfully proved. Although working under the disadvantages of an ill-constructed, half worn-out air-furnace, the produce of the first process was encouraging. The mine, with its present prospects, with care in the management, there is good reason to believe, might remunerate the adventure, although I do not think, without further discoveries, that it will ever be a first-class mine."

In the *Mining Journal*, London, 1854, vol. xxiv, p. 264, reference is made to this mine. Four shafts, from 100 to 300 feet deep, and numerous levels are mentioned, and the erection of a furnace recorded.

Mr. H. Clements, son of the original owner of the Summerhill Estate, informed the Writer that the mine was discovered by a stonemason named Rex, who was working the soapstone, in which the first indications of copper were found, on the Gilmandyke Creek, about a mile from its junction with the Campbell River. This first vein was about 2 feet thick, in hard rock. It was sunk upon or about 90 feet, but was abandoned for a more promising lode about a quarter of a mile distant. The second lode was opened by two shafts and an adit for about 300 feet or more. The lode consisted of yellow sulphide, from 4 to 6 feet in thickness, estimated to yield 10 per cent. dressed. Mr. Clements states that the smelting process on the ground consisted of heap-roasting and reverberatory smelting; but judging from the frequent occurrence of prills of metallic copper in the slag, the latter was badly performed. Probably not more than 20 tons of copper were despatched from the mine. Operations ceased upon the discovery of gold

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in 1851, arrangements being made by the company for suspension of work for a year. Operations were subsequently renewed, and continued until 1858. After the company finally abandoned the property, work was carried on for a few months by a Mr. Peck. No particulars are available of the output after the renewal of work. Very little indeed was to be seen for the capital expended.

In $\frac{1888}{p.\ 126}$ Chief Inspector Slee reported that a shaft had been sunk about half a mile north of the old Summerhill Mine, on a chute of good ore, 1 foot thick, between well-defined walls. A large outcrop of gossan occurs further up the hill.

In $\frac{1891}{p.\ 79}$ the lodes were again being tried. Ore to the value of £500 is reported to have been sent away; 11 tons 4 cwt. of ore, picked from the old heaps, yielded 11¼ per cent. of copper at the English and Australian Company's Works at Waratah.

Taken up by F. Tapson in September, 1901. Unwatering completed in 1902; shaft deepened to 200 feet. Stoped on north side on a slant up to old workings.

Reverberatory furnace erected; produced about 50 tons of 50 per cent. matte.

Sank Buller's Shaft (on Box Ridge) about half a mile north, from 50 to 100 feet. Extracted 30 tons for test. Ore yellow sulphide making largely into pyrrhotite with depth.

The main shaft in Summerhill Lode, at 200 feet is reported to have cut through lode. At this level it was split by slate and quartz—1 foot 3 inches of good yellow sulphide on hanging wall, and 6 inches on footwall.

Inspector B. Sawyer reported (P.B. $\frac{1902}{04}$) three lodes striking N. and dipping E. The "Main," or "Summerhill" Lode, being opened by various shafts—Nos. 2 and 3 lodes (on Box Ridge) being each opened by shafts 100 feet deep. The latter are described by Mr. Sawyer:—"Box Ridge is situated northward from the old Summerhill Lode, at a distance of a quarter of a mile, here two ore bodies have been opened up. No. 1 was formerly worked by Mr. L. Lloyd to a depth of 100 feet, and a length of 150 feet. The No. 2 ore body runs parallel to No. 1, and distant therefrom about 100 feet. The shaft is vertical for 30 feet, then it follows the underlay of the lode down to 100-foot level, where the ore channel opened out and a body of chalcopyrite in a quartz gangue was worked for a length of 16 feet, and an average width of 2½ feet. This body appears strong in floor and southern end of shaft."

Aided to continue 100 feet shaft to 150 feet. Work ceased at 130 feet, as prospects had not improved.

Subsequently held for a brief period by the Lyndhurst Railway and Mines, Limited, in 1905, in an endeavour to procure copper flux for the Lyndhurst ores. Some ore raised, and some taken from surface.

Sunny Corner Division.

Sunny Corner, parish Castleton, county Wynyard.—Apparently the first official mention of copper at Sunny Corner is that contained in the Annual Report of the Department of Mines for 1876, page 78, wherein the Mining Registrar states that the copper mines at Sunny Corner were at a standstill. The ore had been taken to the Bowenfels Smelting Works, but had not paid expenses.

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The lodes at Sunny Corner were first worked exclusively for gold; but about 1881, Mr. H. Y. L. Brown sampled them, and found that their principal value was in silver. Several companies were shortly afterwards formed, and blast furnaces erected. The first—a Pacific Smelter—was started in August, 1884. Whilst the kindly oxidised ores were abundant, smelting operations were successfully maintained. When, however, these were exhausted, great difficulties were encountered in treating the lower-grade refractory sulphides beneath, which consisted of a mixture of sulphides of iron, zinc, lead, copper, arsenic, antimony, &c. Operations were, however, carried on until the heavy fall in silver value, which banished any hope of profitable working under existing conditions.

All the Sunny Corner lodes carry more or less copper which, in smelting, is obtained as matte:—

In $\frac{1888}{p.89}$ 24,972 tons of ore from the Sunny Corner Proprietary Mine yielded 201 tons of lead, 309 tons of copper, and 1,256 tons of matte, containing 319,324 oz. of silver and 2,300 oz. of gold.

In 1890 the Phœnix Mine passed into the hands of the well-known copper smelter, Mr. Lewis Lloyd. Nine hundred tons of cupriferous ore were raised and despatched to his Eskbank Smelting Works.

In $\frac{1891}{2000}$ the Nevada Mine produced 110 tons of copper matte from 680 tons of ore smelted at the mine.

The Sunny Corner Proprietary produced 344 tons of copper from 34,046 tons of silver and gold ore treated during the year, and 77 tons in 1892.

Between 1888 and 1895 (inclusive) the Sunny Corner Company produced, according to its shipping register—6,162 tons 10 cwt. 3 qrs. 23 lb. of matte, containing 1,109·25 tons of copper; 10,752 oz. of gold, and 1,361,676 oz. of silver. The company paid fifteen dividends, amounting to £91,200, equal to 28s. 6d. per each £1 share. After the company ceased operations smelting was carried on by Mr. J. K. Charlston until the serious fall in the price of silver. According to Mr. Charlston's books, the average contents of the ores smelted have been—"Copper, 0·79 per cent.; silver, 7 oz. 8 dwt. 13·6 grs. per ton; gold, 1 dwt. 16·7 grs." The total cost of production, including rent of leases and additions to plant, amounted to 29s. 1d. per ton of ore.

Attention was directed to the Nevada Mine in 1898, as it was reported to contain a fair proportion of copper, which, with its gold and silver contents and silicious gangue, rendered it serviceable for fluxing copper matte. The following analyses were made from a sample selected by the late Government Geologist, Mr. C. S. Wilkinson. (Annual Report, 1886, page 140):—

	No. 1.	No. 2.
Oxide of iron and alumina	24·18	26·31
Insoluble silicious matter	46·63	51·02
Lead	9·34	6·25
Copper	5·06	4·02
Bismuth	·88	trace.
Antimony	·43	„
Arsenic	·90	„
Sulphur	12·42	9·32
Manganese	trace.	trace.
Chromium	„	„
Undetermined, loss, &c.	·16	4·08
	100·00	100·00

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Bathurst Mining District—*continued*.

Oberon Division.

Tarana.—Six miles from—along Tarana—Diamond Swamp road, in a north-east direction from Tarana in G. Kemp's C.L., portion 96, parish Kusdale, county Roxburgh.

Inspector D. Milne (P.B. $\frac{2}{0}\frac{2}{7}\frac{4}{4}$) reported a large quartz formation in porphyry. Strike N. and S., nearly vertical; showing specks of yellow ore, but not in payable proportion. Aided to continue shaft to 50 feet. Progress: Country hard. Ore shoot 9 to 10 inches wide at 40 feet. Another bunch showing at north end.

Trunkey Division.

Trunkey District.—Two copper lodes occur near Trunkey—one near Kempfield (which see) and the other near Bombah. The former was worked off-and-on, but not with much success. The latter was equally unproductive.

Copper ores are also reported at Scrubby Rush, Sounding Rock, and Tiger's Hut. A sample from the latter, $\frac{4}{1}\frac{4}{7}\frac{4}{4}$ yielded from 12 to 14·69 per cent. of copper.

Oberon Division.

Tuglow District, county Westmoreland.—For some years copper ores have been known to occur in this district, but little practical effort was made to develop them until about 1896. Mr. W. J. Bouchier, of Clover Hills, near Tuglow, who worked a lode in portion 52, parish Banshea, supplied the following information, under date of May, 1898:—"The lode in portion 52 has a thickness of about 5 feet. Two shafts have been sunk 30 and 45 feet. From one of these, 36 tons of ore were extracted for an average yield of 14 per cent. of copper, 10 per cent. of lead, and 5 oz. of silver, and 2 dwt. gold per ton. The outcrop is gossan, but at the depths quoted sulphides of copper and lead are encountered.

Inspector H. Hooke, who visited Tuglow about this date, states that Bouchier and party sank to a depth of 60 feet, on what appears to be a true fissure vein, averaging 3 feet in thickness, and containing ore rich in copper, and which has also yielded as high as 17 dwt. of gold per ton.

The lode has a N. and S. strike in slate country, and dips somewhat flatly towards the west. Walls well defined.

About half a mile south of this was Cunningham and party's claim, in which a vertical shaft was sunk to intersect a well-defined vein.

Still further south and within a quarter of a mile was Cotton and Fraser's claim. Their main shaft had been sunk to a depth of 45 feet, on a contact lode between diorite and slate country. Strike of lode N. and S., dip easterly. Bunches of good grade ore occur at the junction and extend for some feet into the slate.

Under date 15th March, 1899, Mr. McLeay, warden's clerk, Burraga, wrote:—"That at 60 feet water was getting troublesome. A sample of copper pyrites with galena and zinc-blende forwarded yielded ($\frac{2}{3}\frac{3}{0}\frac{4}{4}$)—copper, 10·73 per cent.; lead, 23·02 per cent.; zinc, 13·10 per cent.; and silver, 9 oz. 1 dwt. 20 grs. per ton."

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Fourteen tons from Cotton and Fraser's Mine, treated at the Smelting Company of Australia's Works, Dapto, returned 9 per cent. of copper and 16 dwt. 22 grs. of gold per ton, the ore being unpicked. Thirty tons were ready for despatch. Native copper appears along the footwall of the lode.

The cupriferous belt at Tuglow can be traced for some miles, and limestone occurs in conjunction.

Aid was granted for sinking 50 feet on a copper vein in Dun & Co.'s C.P., parish Drogheda, county Westmoreland, on Shepherd's Creek (P.B. $\frac{21}{5}\frac{7}{5}\frac{5}{5}$). Water proved heavy—evidently fruitless.

During 1900 prospecting was continued in Bouchier's, and Cotton and Fraser's sites. Twenty-five tons were raised from the former, and disposed of for £100. (Ann Rept., 1900, page 55.)

In 1906 Bouchier's Mine was reopened by a Yerranderie syndicate, who subsequently formed the Tuglow Copper Mining Company, Limited, in March, 1907.

In July, 1907, the main shaft in Tuglow Mine was 130 feet deep on a small body of 20 per cent. ore.

Fifty tons of ore shipped to Swansea for experimental purposes.

Orange Division.

Wallaby Rocks, between Cadia and Cadia Extended Mines (which see). Poor copper ore in felspar porphyry.

Cowra Division.

Waugoola Creek Copper Mine.—This mine (which was first opened some years previously), was reworked in 1898. Inspector D. Milne, stated that at the 104-foot level the lode was 6 inches thick in the shaft, but occasionally it increased to 3 feet in bunches. The following parcels of ore have been despatched to the Lithgow Smelting Works:—

30	tons realised	£600 net.
7	"	98 "
7	"	114 "
44	tons realised	£812 net, equal to £18 9s. 2d. per ton.

About half a mile south of Waugoola Creek, on the travelling stock reserve, a large quartz reef, about 2 feet thick, strikes north and south through slate country, and carries stains of copper carbonates, which also occur in the walls.

Orange Division.

Wellwood.—The Wellwood Copper Syndicate began prospecting operations in Wellwood paddock, near Lucknow, in 1907.

Cowra Division.

West Hill Lode, parish Killingworth, county Bathurst (on Cooley's Estate, 6¼ miles from Woodstock on Cowra-road)—Inspector J. Polkinghorne reported (P.B. $\frac{21}{5}\frac{21}{5}$):—Gossan with small veins of copper ore in slate and schist. Aided to sink from 25 to 125 feet. At 43 feet—Small copper-stained leaders between well-defined walls.

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At 94 feet.—Occasional bunches of copper ore, arsenical pyrites, and traces of gold.

At 115 feet—Lode 5 to 6 feet wide; carbonate ore on footwall in winze.

At 125 feet—Prospects reported good, but not payable.

Woodstock (*see* Burley Jacky, Belmore, and Waugoola Mines).—Woodstock, on the Blayney-Cowra railway line, is situated in a belt of andesitic rock, more or less cupriferous, which extends into the adjoining Carcoar and Blayney districts. A considerable amount of prospecting has been carried out in the neighbourhood of Woodstock, frequently occasioned by the superficial stainings on the andesite outcrops. These have often led to useless expenditure, as no defined ore bodies have been found in the solid rock, which owes its deceptive colouring to decomposition of sparingly distributed particles of indigenous metallic copper. Near Sugarloaf Mountain, on Cliefden Station, native copper occurs in Smith and McGuiness's shaft, and also in Rothery's Mine near by. In the former instance the copper is in an amygdaloidal andesite, both in the solid and in the amygdules.

In addition to the mines mentioned, copper ores occur in the following localities:—Purcell's land, about 2½ miles northerly from Woodstock; opened in 1895 by two shafts 40 and 60 feet deep. Carbonates and grey sulphides occur, much mixed with the country, but no true lode was proved.

From Nobby's Mine, Woodstock, the Under Secretary for Mines reported $\frac{1898}{p.42}$, that 150 tons of ore were sold for £620.

In addition to the above lodes, the Writer has examined others at various times:—The Cowra Mine, at Bald Hills, about 3½ miles south-west; Russell and party's, 4 miles south-west, which had an outcrop of about 4 inches and a thickness of 2 feet at 17 feet; strike north and south. Phœbe and party's Mineral Lease 51, about 5 miles south-west of Woodstock, where a shaft had been sunk 70 feet on a lode consisting of quartz and clay with carbonate and oxide of copper; strike N. 60° W. Jones's claim, south-east of Woodstock, vein 4 inches, consisting of carbonates and sulphide. T. Austin and party's, half a mile north of Belmore Mine at the junction of sedimentary and intrusive rocks. Bartemote and Hudson's, portion 71, parish Kenilworth, county Bathurst; here shafts were sunk thirty-five years ago in soft schistose slate, striking north and south, and carrying a little copper carbonates with quartz veins; also at Wood's Creek, 4 miles south of Woodstock. In Cooley's Estate, Westville, 7 miles from Cowra, aid was granted to sink on a lode channel having well-defined walls. The slaty dig between the walls carries thin copper-bearing leaders. Aid granted for 100 feet of sinking.

In 1899 Inspector H. Hooke reported (P.B. $\frac{1899}{39}$):—Copper-bearing slate in F. Rowland's land, 3 miles north of Woodstock, and 1 mile south-east of Burley Jacky Copper Mine.

Aid granted to continue sinking to 100 feet. A thin seam of copper ore cut, prospects poor; apparently abandoned shortly after test began.

On T. Hemsley's land, 5 miles north of Woodstock, parish Kenilworth, county Bathurst, Inspector G. Smith reported (17/7/06):—Quartz containing copper ores, in andesite. Strike N. and S., vertical, shaft, 21 feet; aided to sink (P.B. $\frac{1906}{0.46}$) to 46 feet. At 32 feet very hard. Work abandoned.

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BATHURST MINING DISTRICT—*continued.*

Rockley Division.

Wiseman's Creek Copper Mines (known also as North and South Wiseman's, and Eyrie South Mine), about 22 miles from Bathurst, and 12 from Brewongle railway station.—In October, 1873, the English and Australian Smelting Company, Newcastle, treated the following parcels of copper ore from Wiseman's Creek, which probably represent the first extracted:—

9 tons 5 cwt.; yield, copper, 13 per cent.
4 „ 14 „ „ „ 10¼ „

The first official record is embodied in the *Mineral Statistics of New South Wales*, $\frac{1873}{p.\ 123}$. In it the Wiseman's Creek Copper Mining Company was reported to be working a lode at Wiseman's Creek, striking N. 30° W., with a slight dip to the west. It had been proved to a depth of 120 feet, where it had a width of 20 feet. Seven hundred tons of ore had been raised and 350 sold at an average of £7 per ton. Assays yielded from 9 to 17 per cent. of copper, an equal amount of lead, and traces of gold and silver. Fourteen men were employed.

In the Annual Report of the Department of Mines for the same year, pages 142 and 145, assays by Professor Liversidge are published, viz.:—

Carbonate ores yielding, from 16 to 27 per cent. of copper.
Sulphides „ 9 to 10 „

The above were associated with zinc and quartz in a lode 18 feet wide; depth 100 feet.

In $\frac{1873}{p.\ 77}$, the Mining Registrar reported that smelting works had just been commenced, and that the ore had been found to contain copper, lead, zinc, silver, and gold.

In $\frac{1874}{p.\ 117}$, ore was being raised. In this year the mine was inspected by Mr. C. S. Wilkinson, who reported as follows:—"The lode is in talcose schists, which dip S. 79° 45′ W. at 63°. It occupies the fissure of a fault, and strikes N. 15° W., and has a varying dip generally to the east. The ore occurs in bunches along the course of the fault and in offshoots from it. These bunches and shoots of ore, together with some veins of quartz, are of irregular thickness, being from 1 to 18 feet. The ore is of a very mixed character. It consists of green and blue carbonates, sulphides, and black oxide of copper, with the sulphides of lead (galena), zinc (blende), and iron and arsenical pyrites; occasionally a little native copper is met with. Occupying, as it does, the fissure of a fault, the lode will doubtless prove to be a permanent one in depth."

In $\frac{1875}{p.\ 97}$, under the head of "North Wiseman's," the mine was reported in full work. The main shaft had reached 162 feet and the lode was being driven on at that level. Thirty to 40 tons of ore per month were being raised of about 8 per cent. grade; twelve men employed.

In $\frac{1876}{p.\ 1}$ work was continued up to November, £1,750 worth of copper ore being obtained.

In 1880 the mine was closed.

In $\frac{1884}{p.\ 47}$ work was being carried on, but unremuneratively. Payable prospects of silver being obtained, a number of leases were taken up hereabouts.

In 1888 and 1889 a fresh attempt was made—by Messrs. E. A. Baker and Sons—to work the lode under the name of the Eyrie South Copper and Silver

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Mine; but the effort was unsuccessful, and the mine, which is on private land, has since remained idle. The ores, as already described, are of a refractory nature, zinc sulphide predominating—a feature of the lodes in this locality. A reverberatory furnace was erected but never used.

In 1901 Hunter, Wiley, and party drove 580 feet, and sank shafts 30 and 140 feet in the southern or South Wiseman's Creek section. (Annual Report, Department of Mines, 1901, page 54.)

In 1907 a little prospecting in north tunnel was done by the Hon. A. J. Gould, under a purchase option, which was subsequently abandoned.

A considerable amount of work has evidently been done in the early days of copper mining in this locality, judging by the surface evidence.

The Writer is indebted to the late A. G. Thompson, solicitor, Bathurst, for the following particulars from early records in his possession:—

The North, or original "Wiseman's Creek Lode," is described as outcropping for a length of 20 feet or more, and a width of 6 to 8 feet. Operations began at this site, and later about 200 feet south. No capital put into the mine; which was worked so as to pay its way from the start.

A contract was entered into with the old Esk Smelting Company for sale of ore at a fixed price per ton on a minimum basis of 5 per cent.; the price believed to be £1 per ton, and rising 12s. 6d. per unit. This contract continued for about five years, during which about 6,000 tons are said to have been delivered. The only original vouchers and returns extant cover a period of three years, and to that extent can be verified. During this period about 3,400 tons of ore were sold, averaging 10·6 per cent.; returning something over £13,000.

This section of the workings is not now open to inspection, the shafts being beyond repair. It was opened by shafts and shallow open cuts at a considerable distance from the tunnel site in the north bank of Wiseman's Creek, and a surface height of probably 200 feet above it.

The sulphide ore lying at grass is very zincy, as will be seen in the following assay of an average of this class, taken from the small heap at surface:—

No. 08-914—Copper	4·65	per cent.
Zinc	21·57	„
Iron	8·54	„
Sulphur	23·16	„
Silica	21·56	„
Gold	2 dwt. 4 grs.	per ton.
Silver	4 oz. 4 dwt. 22 grs.	„

From the north tunnel at the creek level, a small quantity of sulphides extracted during Mr. Gould's option yielded an average of:—

No. 08-919—Copper	11·05	per cent.
Zinc	5·73	„
Iron	10·92	„
Sulphur	14·92	„
Silica	47·30	„
Gold	2 dwt. 4 grs.	per ton.
Silver	2 oz. 18 dwt. 19 grs.	„

The South Wiseman's Creek workings are across the creek on the southern continuation of the strike, which between the two sections bears N. 20° W.

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BATHURST MINING DISTRICT—*continued.*

The southern section has been opened in the past by two tunnels and several shallow openings—and a large open cut—where a strong gossany lode is still showing in the face; south of this, however, costeens fail to discover it. The latter are about 180 feet above the creek level. The lowest tunnel is 25 feet above, and the second, 80 feet; the open cut 140 feet. The material tipped from the tunnels is largely pyritic schist.

Oberon Division.

Yates' Tarana Prospecting Syndicate, portions 2 and 29, parish Eusdale, county Roxburgh, 4½ miles east of Tarana Railway Station.—Shaft 18 feet, copper sulphide reported 2 feet 6 inches wide. Average assay value—copper, 10 per cent.; silver, 5 oz.; gold, 2 dwt. per ton.

Parallel lode—shaft 16 feet; silver-lead ore 1 foot 6 inches wide. Assay value—lead, 25 per cent.; gold, a trace; silver, 20 oz. per ton.

Other samples yielded:—

No. 06-6610—Magnetic and hematitic iron ore with copper pyrites:—
Copper, 6·05 per cent.
Gold, a trace, per ton.
Silver, 12 oz. 18 dwt. 1 gr. per ton.

No. 06-6611—Copper pyrites with quartz and zinc-blende:—
Copper, 16·92 per cent.
Gold, a trace per ton.
Silver, 3 oz. 17 dwt. 7 grs. per ton.

Yorkey's Creek, Bourke's property, about 1 mile from Mount Victoria—Jenolan-road, at 11-mile peg. Portion 214, parish Lowther, county Westmoreland.—Copper sulphide with specular iron.

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CLARENCE AND RICHMOND MINING DISTRICT.

Copmanhurst Division.

Busy Bee Copper Lode, parish Pucka, county Drake, about 1 mile north-westerly from Fine Flour Mine.—Located by T. and C. Smith, after discovery of shode stones by J. Torrance, in April, 1907.

In July, shaft down 20 feet, exposing a seam of rich grey ore 3½ inches thick. Width of ore channel not then proved, but thin seams of ore and crushed channel rock at intervals in width of shaft.

Strike N. 20° E.—vertical. The ores consisting of rich grey sulphide, carbonate and oxide show derivation from intrusive hornblendic rock. Insufficient development to indicate character and extent of lode.

A sample taken from a small opening on strike north of shaft, where the lode is capped with silicious gossan, yielded:—

No. 07-5415—Copper, 0·32 per cent.
Gold, 13 grs.
Silver, 1 dwt. 15 grs. } per ton.

Cangai Copper Mine.—Worked by the Grafton Copper Mining Company. M.Ls. 1, 2, 3, parish Kaloe, county Gresham. About 26 miles by team road from head of navigable water at Copmanhurst, Clarence River, and 46 miles from Grafton.

Strike about N. 60° W., dip S. 30 W., slight in M.Ls. 1 and 2.

Cangai country rock is puzzling in its petrographical aspect. The following specimens have been examined by Mr. G. W. Card, Curator and Mineralogist, with indeterminate results; though in the field much of the rock bears close physical resemblance to felsite.

6992—*Granulite*, from footwall.

6995, 6997, 6999 } Very opaque fragmental rock, presumably tuffaceous. From road cutting, west side.

6996—Apparently tuffaceous—between E. tunnel level and M.L. 3.

Cangai lode was discovered accidentally by J. Sellars whilst wallaby shooting in August, 1901. His attention being arrested by blue and green carbonates showing in a large block on highest point of outcrop.

Taken up by Sellars and party as M.L. 1, in 1901. Prospectors despatched about 5 tons of oxidized ore to Waratah, which returned 22 per cent. of copper.

From the first shaft sunk near point of discovery, about 80 tons of oxidized ore were raised, yielding from 22 to 34 per cent.

The outcrop on the top of the ridge, which carries a little carbonate and thin films of cuprite, would, when crushed, be suitable for fettling.

McLean and party discovered western continuation of lode, taken up by P. Kritsch and party as M.L. 2.

Corry and party took up the eastern extension as M.L. 3. The latter was sold to Melbourne investors under the title of "Cangai Copper-mining Company," who extracted about 300 tons of ore, despatched to Newcastle and Melbourne.

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Scene of Original Discovery of Cangai Copper Lode, by J. Sellars, August, 1901.

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M.La. 1 and 2 were subsequently acquired and amalgamated by the present Grafton Copper-mining Company, and subsequently M.L. 3; also the Sir Walter Scott Gold-mine and machinery, about 2½ miles distant, the auriferous ore in the latter being regarded as a potential flux for the Cangai basic ores, in possible future treatment.

Mr. Warden Fitzhardinge reported the discovery in 1901 (after about 40 tons of ore had been despatched), and recommended a reservation for mining purposes, the latter (No. 34,672) was proclaimed 12th July, 1902.

Progress of development.

1902.—The official report for this year was to the effect that in Harps and party's lease [? Sellars and party.—J.E.C.], Yantalla Creek, two shafts had been sunk, the deepest 40 feet. Four tons of ore had returned 22 per cent. of copper, 2 dwt. of gold, and 13 dwt. silver per ton. (Ann. Rept., 1902, p. 56.)

1904.—Grafton Copper Company formed; 350 tons of ore disposed of for a return of £4,660 (*ibid.*, 1904, p. 47).

1905.—Operations energetically carried on; 291 tons disposed of for £4,805 (*ibid.*, 1905, p. 46).

The enriched ores of the superficial zone continued to be despatched by team to Copmanhurst, until permanent smelting began at the mine in May, 1906.

In each of the lenses opened at a shallow depth, oxidized ores gave place to yellow sulphides, the latter of great purity. Whenever Customs smelting returns dropped below 20 per cent., lower levels were abandoned for higher, taking the zone of maximum enrichment, which rose from both east and west sections in conformity with the physical contour of the outcrop.

The following assays of average samples taken by the Writer at date of first inspection in June, 1905, convey an idea of the richness of the lenses then being opened. It may be noted that these grades were rejected when ore was being prepared for market, only the cream of the enriched sulphides being despatched:—

Assay No.	Description.	Copper, per cent.	Gold, per ton.	Silver, per ton.
			oz. dwt. gr.	oz. dwt. gr.
05-2356 ...	Compact sulphide ore, M.L. 1, east side, 7 feet wide.	17·57	0 3 9	1 2 21
05-2357 ...	Compact sulphide ore, "Wombat Hole," M.L. 2, west side, 8 feet wide.	16·80	trace.	1 7 5
05-2358 ...	Compact sulphides, No. 1 shaft, west side, 16 feet deep, 4 feet wide.	17·46	0 4 8	1 3 23
05-2359 ..	Dredgy ore, east end of drive from end of rich lens in "Wombat Hole," west side, 4 feet wide.	4·26	trace.	1 12 16
05-2360 ...	Gossan from cap of lode between tunnel and No. 1 shaft, M.L. 2, west side.	.....	0 4 8	1 1 19
05-2361 ...	Shipping ore from enriched or top portion of lens in M.L. 1, east side.	23·17	trace.	1 11 14

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CLARENCE AND RICHMOND MINING DISTRICT—*continued.*

The average quality of the ores thus sold is illustrated by the following returns, received between 21st June, 1902, and 30th June, 1905[1]:—

Ore despatched, 760 tons 18 cwt. 3 qrs. 26 lb.=yielding copper, 207 tons 7 cwt. 3 qrs. 1 lb., equal to 27·2 per cent.

Total ore despatched to 1st September, 1905=944 tons.[2]

Total ore smelted to 30th June, 1908=7,912 tons for 1,529 tons of matte, containing 848 tons of copper.[3]

Smelting Plant—Cangai.

Erection of two 40-ton reverberatory furnaces begun in September, 1905. Smelting started January, 1906, for a brief period. Permanent smelting began May, 1906.

No. 3 furnace—70-ton—started June, 1907.

No. 4 under construction in May, 1908.

Temporary cessation of first smelting campaign due to inferior sand used in furnace bottoms; the granite detrital sand of the adjacent South River bed proving too fusible owing to admixture of basic materials. Satisfactory bottoms subsequently formed of pure silica sand from Whiteman's Creek, near Copmanhurst, derived from the Clarence Coal Measure Sandstones.

The first furnace difficulties were also increased by insufficient silica in the rich basic ores smelted, hence the resultant ferrous oxide attacked the fire-brick of the furnace.

Cangai possesses the advantage of very basic sulphides capable of carrying a large percentage of poor silicious or slaty ores—such as occur between the main lenses.

For fettling, an admixture of river sand and local clay answers satisfactorily. A local fire-brick is now also being substituted at about one-fourth the cost of the previously used Bulli brick.

Limestone is not used, sufficient lime occurring—as calcite streaks—in the lode channel, particularly in "A" level, to render the ore self-fluxing. If required at any time an excellent limestone occurs in M.L. 20, parish Braylesford, on Purgatory Creek, about 12 miles from Cangai, and 2 miles from the team road to Copmanhurst, which could be obtained as back loading.

The following analysis reveals its composition:—

No. 05-3839—Calcium carbonate	97·76	per cent.
Magnesium carbonate	trace.	
Alumina and oxide of iron	0·50	,,
Insoluble in acids	1·60	,,
Moisture at 100° C.	0·02	,,
Strontia	trace.	
	99·88	

The sulphide ore is roasted in clamps of one or two hundred tons each, a process requiring six to eight weeks, according to size of clamp.

Furnace charge of 40-ton furnaces.—2·5 tons roasted ore, with an occasional barrow of raw ore.
·5 ,, roaster slag.
Time, about 7 hours.

Furnace charge for 70-ton furnace.—3·5 tons roasted ore, with occasional barrow of raw ore.
·5 ,, roaster slag.

[1] Supplied by Mr. W. Zeitsch, Director. [2] Supplied by E. R. Woodward, Legal Manager, [3] Supplied by J. H. Gibson, Secretary.

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Cangal Smelting Works and Roast Heaps.

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It is customary to run the three furnaces on ore for a time, then one on 1st matte.

The roaster charge is about 9 tons matte, which is brought up to 70 per cent. metal in a 24-hours roast.

Moulding sand is obtained from South River close by.

Cangai Mine is situated on the north side of a picturesque valley formed by Yantalla or Stockyard Creek and the Mann or Mitchell River, locally known as the "South Arm" (of Clarence River); practically shut in by high ranges. The bold eastern front of the New England plateau—here named the Gibralter Range—closes in the western view.

The valley of Yantalla Creek is most suitable for village settlement, possessing gentle lateral slopes. The creek joins the river about 120 chains below the smelting furnaces. A permanent water supply of great purity is thus within easy reach. The great fall of tributary perennial streams from the western plateau offers exceptional inducement for economic generation of electro-motive force; Dundahra Creek, the nearest and most suitable, being already contemplated by the company for this purpose.

If the mine continues to develop as at present indicated, cost of haulage, drilling, lighting, pumping, &c., can be considerably reduced by installation of an electric power plant.

From the accompanying plan and section it will be seen that the mine is most favourably circumstanced in regard to working conditions. Gravity transport is largely available from mine to smelters. Situated, moreover—in its highest outcrop on the top of a saddle formed by a spur from the main northern range—the lode is workable by tunnel to the 500-feet level on the west side, and to about the 300-feet level on the eastern.

"Mullocking," or filling, can also be economically effected from the steep natural slope above the passes in the channel.

Excellent mine timber and firewood are abundant. The greatest want is a properly constructed road to the head of navigation on the Clarence River. Recently the existing road has been considerably improved by a cutting obviating three crossings of the South Arm channel.

The company has constructed about 2 miles of excellent roadways between the smelters and the eastern and western workings, metalling them with mine waste.

On the east side an ore hopper of 200 tons capacity is connected with the mine tramways, all levels being connected therewith.

From this hopper a cable-line tram connects with 300-ton triple chamber ore-bins, in the valley, from which the ore is delivered into carts or trucks and thence along graded roadway to roast heaps and smelters—a distance of 65 chains.

On the incline cable between hopper and ore-bins the descending full trucks draw up the empties—a passing loop being constructed about midway.

On the west side, ore-bins have been constructed at A and B levels, of a capacity of 200 and 75 tons respectively. Ore passes from upper mine levels to lowest, thence trucked to ore-bins and hoppers.

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CLARENCE AND RICHMOND MINING DISTRICT—*continued.*

Progress of development.

To July, 1907, four shoots of ore had been proved in the lode channel, 50 to 150 feet in length, with a width of 1 to 13 feet. Pitch of lenses almost vertical. Horizontal proving along strike of lode, 2,000 feet. Depth proved by shafts and levels, 510 feet.

Total distance between extreme end and west provings on ore—about 1,680 feet. Levels are being run to meet from both sides.

"*A*" *level.*—Starts in M.L. 2 from the west side 510 feet below the outcrop at site of original discovery on saddle. This represents the lowest natural level attackable by tunnel. Starting as an entering cross-cut at 115 feet, a branch drive north-easterly connects with McDonough's shaft sunk in ore.

At 315 feet the lode was cut in main drive, ore continued in channel in strings, small lenses, and particles in the crushed channel filling to 450 (at date, 3rd July, 1907). Width of channel not defined in places. Scabs of ore passing into walls. The class of ore here followed requires furnace or mechanical concentration, preferably the former so far as is possible. With the ore, and in the crushed channel filling, veins of calcite occur, which will aid in fluxing. At about 500 feet on this level, the winze in rich chalcopyrite followed down from surface through the upper levels, was encountered.

The ore channel in McDonough's shaft and branch drive dips towards main lode in "A" level at an angle of about 50 degrees, and should intersect at a lower level.

The quality of the ore from "A" level before striking the winze lens is shown in the following assay:—

No. 07-5412—	Copper	11·92
	Iron	25·48
	Sulphur	25·36
	Silica	22·50
	Gold, 1 dwt. 2 grs. per ton.	
	Silver, 5 dwt. 10 grs. per ton.	

This lens at "A" level was 15 feet wide but not solid (according to the manager, Mr. W. J. Mulligan), a fair proportion, however, being direct furnace ore, the balance to 2nd heap.

West side, "*B*" *level.*—70 feet above "A" level; was in 570 feet on the 3rd July, 1907. The channel at first carried 8 inches or 9 inches of carbonates, then sulphides as in "A" level, but not so wide.

At 340 feet, rich, solid yellow sulphide was struck and driven through for 60 feet, averaging about 8 feet wide. This was stoped up to within 20 feet of "C" level, where it was solid overhead.

For 150 feet beyond this lens, yellow sulphide continued, but thinner, widening, however, in one lens 20 feet long to full width of drive.

At 570 feet a blank occurred, with slight variation in strike, as in "C" level above, which lasted for about 20 feet, when sulphides again came in and continued as far as driven up to October, 1907.

West side, "*C*" *level*—Length, 210 feet (on 3rd July, 1907) along lode from entering cross-cut. Rich sulphides for about 70 feet, of a width of 6 to 13 feet solid. Ore continues along this level for 120 feet, from 1 to 3 feet wide, of a grade of 8 to 9 per cent. Similar troubled conditions encountered as in "B" level, fissure continuous, but lode blank for 20 feet, then ore again, which persisted so far as noted (October, 1907).

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Above the eastern end of the lens rich carbonate ore was shipped away at the beginning of mining.

The "Wombat Hole," on back of "C" level, also yielded rich ore at the above date.

East of the latter is an early shaft; beyond this again the lode outcrops in a small gully, which had not been prospected at date of inspection.

The principal ore bodies occur—so far as proving has extended—in the eastern section, in M.Ls. 1 and 3. Two lodes occur here, and have been opened by shafts, tunnels, levels, and winzes. Cross sections 1, 2, and 3 on the accompanying plan and section of the mine, reveal their thickness, as proved to 14th January, 1908.

The following notes were made of developments during inspection in 1907:—

East side, "E" level.—In main fissure, continued 236 feet along channel; crosscut at 220 feet to "south" lode, distant 25 feet. Ore in main channel in narrow lenses, but of good grade. At intersection of lode at entering cross-cut tunnel, a "rise" to surface. Seventy feet to surface on hill-side. Sulphides here overlaid by high-grade carbonates.

Between "E" and "F" levels, an intermediate level has been driven 85 feet on ore, first black ore, then high-grade sulphide, part solid, part concentrating grade.

"*F*" *level.*—94 feet vertical below "E," and 120 feet below highest point of outcrop.

On "South" lode, which intersects the main lode at an angle, and has developed the best and largest ore-lenses. Driven—at time of inspection—200 feet west along lode from entering cross-cut, and 68 feet east. Solid sulphides for about 180 feet—to July, 1907—varying from 1 to 7 feet in width.

The strike of the south lode is N. 60° W.; that of the north N. 72° W. On the 30th May, 1908, the intersection had nearly been reached,

Winze sunk connecting "E" and "F" levels—in solid high-grade sulphide 3 to 7 feet wide, and widening; the ore tenor equalling 15 to 18 per cent.

West of this lens in "F" level, channel wider but containing only scattered ore.

M.L. 3 section (Melbourne Block).—Main lode opened on level with "E" level. Shaft 40 feet, driven west at bottom for 40 feet, and 30 feet east.

High-grade sulphide, partly enriched, being stoped along this length. Lens wide at top, but narrowed below. Quality shown in assay of average sample:—

No. 06-5411—	Copper	17·95	per cent.
	Iron	30·66	„
	Sulphur	26·69	„
	Silica	9·13	„
	Gold, 4 dwt. 8 grs. } Silver, 1 oz. 7 dwt. }	per ton.	

The "South" lode differs from the main in that it has no appreciable "dig," or crushed filling. The cupriferous rock, however, contains films of calcite.

Since inspection in July, 1907, a fresh lens of ore has been cut between "E" tunnel in M.L. 1, and the Melbourne block, M.L. 3. It has been opened below the tram-line in Greenberg's tunnel. At 50 feet deep this lens showed 6 feet of 18 per cent. sulphide, dipping south. A cross-cut tunnel was started to open it up.

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The nature of the ore bodies, and the systematic development of the mine, are illustrated in the accompanying plan and sections, for which the Writer is indebted to the Grafton Copper Company.

It is essential that the good policy of keeping development well ahead of stoping and furnace requirements should not be departed from, as vertical blanks are as certain to occur as horizontal. Depreciating values, moreover, assuredly wait on depth.

Only by persistently following the ore shoots vertically—to avoid dead work—can the future be insured against surprises.

In view of recent important developments in M.Ls. 1 and 3 below the lowest natural levels available, a main shaft should be started to prove the ore shoots below water-level, it is unwise to work out the richer superficial ores, and leave the lower, and unquestionably poorer, to bear alone the heavier costs of mining and treatment. The richer should carry a large proportion, at least, of the poorer through the furnaces.

The following descriptions of the cross sections of the lode exhibited on the attached plan were kindly supplied by Mr. W. J. Mulligan, general manager (under date 14th January, 1908, with additional notes to 30th May, 1908):—

No. 1 *section.*—Is on the eastern side of the mountain, M.L. 1, from "E" level up to "F," through No. 2 winze, which is 320 feet in from the cross-cut entering tunnel at "E" level. This shoot of ore in the "South" lode has been driven west 118 feet from the No. 2 winze, averaging over 3 feet of solid ore, for 80 feet, and reaching a maximum of 10 feet. It was twice faulted for a few feet, as shown on plan of part of "E" level. At the face at 118 feet it averaged about 3 feet.

No. 2 *section.*—Is the same ore body from "F" level to the surface, the upper portion being rich carbonates, which have averaged about 40 per cent. copper.

No. 3 *section.*—Is the recently discovered lens of solid ore in the south lode on the eastern side; it is about half way between the Melbourne section and "E" level. It was very small at surface, but widened quickly. Has been driven on 64 feet for an average width of 11 feet, with solid ore in both faces. There is every indication of it being the largest lens of ore yet discovered in the mine.[1] A winze has been sunk 10 feet from this level in solid ore.

No. 4 *section.*—Is through the principal ore lens on the western side of the mountain, from "B" level up to surface through "C" level. This lens commences at a point 320 feet from the mouth of "B" level, and extends for 80 feet, when it narrows to a little over 1 foot, and then widens to 3 feet, when it again narrows in, but 2nd grade ore up to the face. All the ore smelted from this lens has averaged over 10 per cent. copper. Owing to the important developments in the Eastern Section, little attention has been paid to the Western of late.

Cangai District.—Gap Creek (Lamb's copper shaft), on track Wongabri to Circular Flat, Cangai Road. Shaft, 25 feet. Quartz, with a little carbonate and sulphide of copper. Assay of an average sample:—

No. 05-2376—Copper, 5·75 per cent.
Gold, a trace (under 2 dwt.) } per ton.
Silver, 6 oz. 10 dwt. 16 grs. }

[1] It was reported in July, 1908, that a face of 10 per cent. ore, 20 feet wide, had been exposed in "I" level, west drive.

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CLARENCE AND RICHMOND MINING DISTRICT—*continued*.

Clarence River District.—The late Mr. W. Penrose, manager of Yulgilbar Station, under date July, 1898, stated that the first copper lode was discovered in this district about 1863 on Ewingar Creek, parish Ewingar, county Drake. A shaft was sunk about 30 feet on a narrow vein assaying about 20 per cent., but no ore was treated commercially. Since that date two other very small lodes have been discovered on Nogrigar Creek, about 4 miles south of the first-mentioned, assays from which are reported up to 14 per cent.; the ground was held, but no real work was being done in the way of proving.

On Gordon Brook Station copper was found near Deep Creek, 12 miles north of Copmanhurst, about 1873; a good deal of work was done, but the lode, though rich, was too small to pay for working. Since that date a lode was opened, and abandoned for the same reason, at Oakey Creek, on the same run.

Mr. E. F. Pittman in $\frac{1}{P.} \frac{8}{3} \frac{7}{7}$, writing of this district, stated that "after leaving Gordon Brook Station the track is over 2 miles of granite, and then again a belt of 1½ miles wide of hard altered slates dipping west of north at an angle of 70 degrees. In this formation occurs a lode of copper ore which has been pretty well prospected, and which, with better facilities for carriage, would probably pay to work."

Messrs. Wilkinson and Slee in $\frac{1}{P.} \frac{8}{3} \frac{8}{0} \frac{2}{4}$, stated that prospecting for copper at Gordon Brook in serpentine revealed no signs of a lode, only a few small veins of copper ore of no value being met with.

The Jakoonbie Copper Mine, now known as Glamorgan, Gordon Brook, was sunk upon to 120 feet, and driven on at the 50-feet and 110-feet levels. Mr. E. F. Pittman, $\frac{1}{P.} \frac{8}{3} \frac{8}{4} \frac{9}{7}$, described the lode as being 4 feet thick and bearing N. 40° E. Sixty tons of dressed ore were smelted at Eskbank, the highest yield being 14⅞ per cent. Near by Mr. Pittman examined a wide gossan lode in granite containing iron and copper pyrites, native copper, and stains of green carbonate.

A sample from Tabulam ($\frac{4}{P.} \frac{4}{3} \frac{9}{6}$) yielded 32·27 per cent. of copper, and 4 oz. 7 dwt. 2 grs. silver per ton.

In 1888 leases for copper were taken up at Yarrakalkiarra.

Camelback Mountain.—In a report, dated 1853, the Rev. W. B. Clarke reported abundant indications of copper and lead near the Camelback Mountain.

Fine Flour Mine, M.L. 3, parish Pucka, county Drake, on west bank of Gordon Brook or Fine Flour Creek.—Discovered in 1905 by J. Torrance and T. Smith. Opened by Messrs. Smith and Wiley. The prospectors sank No. 1 shaft 23 feet and obtained from it 7 tons of dressed ore, which yielded 23 per cent. of copper at Waratah.

The mine was subsequently sold to the present Fine Flour Syndicate, which sank Nos. 2 and 3 shafts 46 and 40 feet (at time of inspection, July, 1907).

No. 1 shaft was full of water, but blocks of ore at grass revealed a thickness of about 12 inches of silicious ore, consisting of massive pyrites in part, with black oxide and carbonate of copper imparting a banded structure; the average value being, probably, 5 to 6 per cent. The lode in these shafts strikes N. 19° E. and dips N. 71° W. at 58°.

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No. 2 shaft contained a little soakage water, but was open to inspection to about 30 feet. Lode channel 12 to 20 inches wide, very poor and mullocky. A little powdery black oxide present, also iron and copper pyrites. Little or no ore at grass; none despatched.

No. 3 shaft.—Lode almost vertical, and distinct in character from that opened in other shafts. Probably a parallel lode. Thickness of fair ore exposed in shaft, 7 inches to 9 inches. A three-quarter inch vein of copper sulphide occurs nearer footwall. Stains of carbonate on footwall side. Native copper and cuprite are also present on west wall.

A cross-cut tunnel was being driven on the east fall from No. 3 shaft about 160 feet below it, which will, if continued, give about 100 feet of backs below the present shaft if not deepened. The distance to drive is considerable and the rock exceedingly hard, the value of the enterprise being very doubtful.

A parallel vein occurs near the creek, which has been opened close to the N.E. corner of M.L. 3, to a depth of 10 feet, revealing a thickness of 1 ft. 6 in. to 2 feet of quartz with heavy pyrites, and a little black oxide and yellow sulphide of copper. An average sample selected from the ore raised yielded:—

No. 07-5414—Copper, 0·45 per cent.
Gold, 13 grs.
Silver, 5 dwt. 22 grs. } per ton.

About 2 chains S. 30° W., a sample of gossan from a small cut in a parallel outcrop yielded:—

No. 07-5413—Copper, less than 0·10 per cent.
Gold, a trace
Silver, 6 dwt. 13 grs. } per ton.

There are indications of other veins west of the main which had not been opened. The latter occurs about 300 feet above Gordon Brook or Fine Flour Creek.

The Fine Flour rocks consist of fine-grained diorite (6989), and another of igneous origin (6988), not determinable from specimen obtained. Further west, between Fine Flour and Busy Bee Mines, an altered hornblende andesite (6991) occurs.

Flintoff's Copper Lode, parish Pulganbar, county Drake.—Subsequently held under the name of Cu Copper Syndicate. Opened about 1887. Re-opened by Flintoff in July, 1907. Strike of channel N. and S., dip W. at 83°. Thickness (at 62 feet) about 3 feet, mostly hard silicious channel rock with calcite joints. Best ore consisting of silicious pyrites with powdery black oxide or subsulphide of copper, worth about 3 to 5 per cent.

In August, 1907.—Arsenical pyrites from a level driven at 62 feet yielded high percentages of cobalt, the following results being obtained by assay from a 3-inch vein on the footwall:—

No. 07-6825—Metallic arsenic	.....	18·04 per cent.
Cobalt	.....	8·90 „
Nickel	.....	0·03 „
Copper	.....	trace.
Iron	.....	5·63 „
Gangue	.....	53·68 „
Gold	.....	trace.
Silver	.....	„

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A sample of copper ore in quartz and ironstone from face of drive 32 feet south, yielded:—

No. 07-6824—Copper, 9·22 per cent.
Gold, a trace
Silver, 1 oz. 1 dwt. 19 grs. } per ton.

In an old shaft 8 or 10 chains distant on south strike, poor silicious ore with stains of copper carbonate is exposed.

The latest developments being a drive south on the lode for 40 feet at the 62-feet level, the last 16 feet being in carbonate ore, assays of which yielded 9·2 per cent. Shaft sunk to 76-feet level. A crosscut from a lower surface level was also being put in to cut the lode—in driving 120 feet in it, two veins are reported to have been cut 1 ft. 6 in. and 2 feet wide, showing a little copper carbonates.

Cinnabar (sulphide of mercury) has also been found in this and the adjoining property. Rich nodules up to several lbs. weight have been found in alluvial, and lode samples assaying up to 1 per cent.

Gem Mine, portion M.C.P. 200, parish Pulganbar, county Drake.—Opened about 1886. Two shafts sunk, now fallen in. Recently re-opened by J. Malone and party. Lode apparently strikes N. and S. No outcrop visible. Large blocks of brecciated gossan raised to surface indicate strong lode of some promise. Thickness of lode probably not less than 2 feet.

Glamorgan Copper Mine, originally known as Jakoonbie, portion 22, parish Pulganbar, county Drake, on Gordon Brook Pastoral Holding.—Opened in 1875. It is recorded that "At Gordon Brook, in the Clarence District, a company has recently started, and has raised 12 tons of ore, but none of the ore has been treated."—(*Min. Statistics*, 1875, p. 92).

In portion 22, and adjoining portions 20 and 21, numerous reefs of quartz and arsenical pyrites occur, containing small proportions of cobalt in association with the arsenical pyrites. From main shaft in portion 22, samples have been obtained from nodular lumps about 6 inches thick, containing up to 3·34 per cent. of cobalt, gold to 1 oz. 17 dwt., and silver to 2 oz. 5 dwt. 17 grs. per ton.

Though copper has been the metal sought in the past, it is doubtful whether it can be profitably extracted from arsenical ores below water-level, unless gold and cobalt considerably enhance the average value. The transition at water-level into refractory arsenide of iron instead of ordinary sulphide, complicates metallurgy and increases cost.

In a new make in No. 2 shaft, however, near by, some silicious—but less refractory—ore has been raised. The copper value of some 30 tons at grass ranges from 7 to 10·5 per cent. No ore has been sent away since previous inspection in 1905.

No. 2 shaft has been deepened to 96 feet; over 5 feet of sulphide ore of the character mentioned above are reported in the bottom.

Casino Division.

Jones' Lodes, close to Wallaroo Lode, in Mugin Wybra Creek, parish Hamilton, county Drake.—Strike N. 35° E., dip N. 55° W.; width, 8 inches. Opened

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by shallow trench and exposed in creek bed. Ore, ferruginous quartz and felsite (?) with zinc-blende, pyrites, and a few copper carbonate stains. An average sample yielded:—

No. 07–5310—Copper, 1·00 per cent.
Gold, a trace
Silver, 16 dwt. 21 grs. } per ton.

A larger lode near by strikes N. 45 E., dip N. 45 W. at 45°. About 4 feet exposed in shallow opening; footwall not visible. Lode carries thin veins of zinc-blende, and a little copper and iron pyrites, very hard and flinty gangue. An average sample yielded:—

No. 07–5311—Copper, 3·40 per cent.
Gold, a trace
Silver, 1 oz. 14 dwt. 20 grs. } per ton.

Just in Time Lode.—In branch of Mugin Wybra Creek, parish Hamilton, county Drake. Strike N. 35 E., dip S. 55 W. at 69°. Discovered by James Farrell in 1907.

Outcrop strong and well-defined—traversing rhyolite with strongly developed fluxion structure.

The main lode averages about 3 ft. 6 in. in thickness, and has been proved by a shaft and shallow openings for a length of nearly 4 chains.

About 8 feet west a vein of a few inches thick shows same character as main body.

Unfortunately the lodestuff is a zinc-copper problem, amenable only to magnetic separation. The close approximation of the specific gravities of the two minerals zinc-blende and chalcopyrite (4·1—4·3 and 3·9 to 4·2) preventing gravity separation. The extremely intimate association, moreover, prevents even rough hand-dressing and picking.

An average sample of the ore raised whilst sinking the shaft to 30 feet (since deepened to 40 feet) gave the following returns:—

No. 07–5315—Copper	6·20	per cent.
Zinc	34·54	,,
Iron	8·96	,,
Silica	20·22	,,
Gold, a trace		
Silver, 1 oz. 6 dwt. 16 grs.	per ton.	

Two other samples from superficial openings along the outcrop gave the accompanying returns:—

	07–5313.	07–5314.
Copper	5·92 per cent.	16·85 per cent.
Zinc	18·97 ,,	12·09 ,,
Gold	A trace per ton.	A trace per ton.
Silver	18 dwt. 12 grs. per ton.	2 oz. 3 dwt. 12 grs. per ton.

Copmanhurst Division.

May Queen Lode, M.L. 1, parish Pucka, county Drake, on Gilmore Range, Gordon Brook.—Lease taken up many years ago for copper; retaken in 1905. Rich magnetic and specular iron oxide occur at the site, associated with limestone and garnet, in hornblende and diorite country.

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The intrusive diorite has absorbed part of the limestone and developed considerable garnet along the contact margin. Along this line prospecting for copper has been carried on, the copper ores being discovered in the garnet. Similar conditions extend along the contact for some miles.

Aid was granted to follow the copper indications on the Gilmore Range, but little was availed of as the prospects were not encouraging.

Casino Division.

Minnie Copper Lode, M.Ls. 10 and 11, parish Ewingar, county Drake.—Discovered in November, 1905. Opened by T. Bassetti, in quartz-felsite.

Strike N.E., dip N.W. at 58°. Opened by two shafts 30 feet and 83 feet, 70 feet apart. Hanging wall well-defined, with slight dig. Footwall probably not yet exposed. Ore on hanging wall, mostly pyrites with occasional patches of rich yellow ore, balance of channel filling crushed and jointed rock. About 1 foot of fairly solid pyritic ore, with other thin streaks in filling. Concentration necessary. Better grade likely to make in short lenses.

From the site of the original discovery—alongside the 30-feet shaft at the south-east end—6 tons of yellow sulphide close to the surface were taken from a small channel, which thinned rapidly both horizontally and vertically.

Four tons yielded 17·5 per cent. of copper at Waratah; and 2 tons yielded 10·5 per cent.

Aid was granted to sink from 55 feet to 105 feet, and to drive from the latter (P.B. $\frac{2}{6}\frac{5}{7}\frac{0}{0}$).

Mr. Bassetti reports that at 83 feet the prospects are about the same as at 55 feet, described above.

The lode had also been opened 4 chains further north-east, with carbonates showing.

Coramba Division.

Mount Brown Copper and Gold Mine, Kangari, between Coramba and Coff's Harbour, P.G.L. 1.—Originally worked for gold. Taken up recently by Zeitsch, Kritsch, and party. Mine unwatered, exposing a 10-feet lode carrying 2 feet of high grade copper ore. A tunnel being driven which, in conjunction with pumping plant, will keep mine unwatered to 156-feet level.

Now held by the Mount Brown Copper and Gold-mining Company.

Three lodes reported—main lode 300 feet long, carrying a little gold.

Gold and copper lode 50 to 60 feet long and 9 feet wide.

Sixteen bags of copper ore yielded 12·2 per cent. of copper at Dapto, and 2 dwt. 19 grs. of gold and 3 oz. 0 dwt. 9 grs. of silver per ton.

Gold crushings totalled 280¼ tons for a yield of 103 oz. 6 dwt. of gold.

Mullumbimby Division.

Mullumbimby.—J. Dwyer's land, 6 miles from Mullumbimby. Thin arborescent films of native copper in quartz and felsite (?), discovered early in 1907. A few shallow openings, deepest 12 feet.

The Rev. W. B. Clarke in Report IX, dated June 24th, 1853, p. 11, stated that carbonate of copper occurs on the slopes of Mount Lindsay, in the Tweed River district.

A sample (08·641) reported to have been obtained near Mount Warning, returned 5 per cent. of copper, and about 11 dwt. of silver per ton.

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Dalmorton Division.

Newton Boyd Silver and Copper Lode, on Mann River, between Glen Innes and Newton Boyd.—Galena and copper pyrites in granite; opened by T. Foley.

An average sample yielded:—

Copper	0·49 per cent.	
Lead	2·22 „	
Silver, 4 oz. 6 dwt. 14 grs.	per ton.	
Gold, a trace		

Casino Division.

Nil Desperandum Lode, on a branch of Mugin Wybra Creek, between Wallaroo and Just in Time lodes.—Strike N. and S. in quartz-felsite. Exposed in creek bed and in shallow cuts. Soft, kindly-looking lodestuff, which may yield bunches of payable ore. None proved at date of inspection, though carbonates freely stain channel filling. Exposed for about 2 chains. Iron and copper pyrites leanly distributed in harder parts.

Samples from the outcrop yielded:—

No. 07-5312	Copper	0·75 per cent.	
	Gold	A trace	per ton.
	Silver	4 dwt. 8grs.	

Nogrigar Copper Lode, M.L. 9, parish Ewingar, county Drake.—Opened by J. McColl in 1893. From ore then extracted, 3 tons sent to Dapto yielded 10·7 per cent. of copper.

Strike about N. and S. in serpentine near junction of sedimentary rock. Old shaft 30 feet deep. Apparently small bunch of ore in serpentine. Joints of rock stained with films of copper carbonate. Recent prospecting a few feet south failed to reveal any trace.

Close by a green-stained quartzite (like amazon stone in appearance) had been superficially prospected; the colour was, however, found to be due to chromium.

Copmanhurst Division.

Pluck Mine.—Prospecting area, parish Pulganbar, county Drake, near north boundary of portion 200. Gordon Brook or Fine Flour Creek. About 15 miles from the navigable waters of the Clarence River at Copmanhurst. Opened about 1883. Re-opened by the present owner, D. Hughes, in 1903.

Strike N. and S., dip west, 1 in 3. Three parallel lodes occur a short distance apart. Main or central lode worked by two shallow level tunnels, the lowest being but 50 feet below the highest point at south shaft. Main shaft required to compete with water making below level of Fine Flour Creek—from the bank of which the lowest tunnel starts.

Aid was granted (P.B. $\frac{21}{07}\frac{88}{88}$) for sinking the south shaft to 80 feet. The lode was reported 2 feet wide at 49 feet. At 69 feet no further sinking, abandoned on account of water and want of adequate appliances to keep it in check.

The lowest tunnel was thereupon driven for over 200 feet to secure 26 feet of backs below the upper tunnel. Further progress is not now possible without capital.

The lode averages about 4 feet wide, and is well defined and likely to be permanent. In the lower tunnel from 1 ft. 6 in. to 2 feet of good ore was

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exposed at time of inspection in July, 1907, consisting of iron and copper pyrites with black subsulphide. The channel filling is partly brecciated, the solid ore being on one wall. Concentration is necessary for full advantage of the metalliferous contents; gangue silicious.

The total output to 15th July, 1907, according to the owner, was 80 tons dressed ore, averaging 13 per cent. of copper.

Potato Copper Lode, N.W. of Busy Bee Lode, parish Pucka, county Drake.—Strike N. 25° E., dip N. 65° W. at 50°. Discovered in 1907 by J. Taylor. Superficial proving only. About 2 feet of copper-bearing lodestuff exposed. Concretions of fair ore gave rise to name.

Walker's Pinch Lode, Scafte and party, parish Kahloe, county Drake. Close to road to Cangai, and to old antimony mine.—Reported 5 feet of quartz with copper pyrites, concentrating ore—best grade up to 7 per cent.

Casino Division.

Wallaroo Lode, parish Hamilton, county Drake, on a branch of Mugin Wybra Creek.—Massive outcrop about 12 feet wide, resembling Drake metalliferous country.

Ore quartz and quartzite with leanly distributed sulphides of iron, copper, and zinc, in intensely altered diorite country. Unopened—exposed in bed of creek. Strike N. and S.

An average sample from outcrop yielded:—

No. 07-5309—Copper, 2·35 per cent.
Gold, a trace
Silver, 1 oz. 8 dwt. 20 grs. } per ton.

Copmanhurst Division.

Wiley's Lode (Dolconda), M.L. 6, parish Pucka, county Drake.—Discovered by W. Wiley. Short tunnel driven before discovery of Fine Flour lodes. Strike N.E., dip N.W. at 73°. Thickness, 2 ft. 6 in. between walls. Orey part on footwall, about 1 foot wide. A little ore extracted, an average sample of which yielded:—

No. 07-5416—Copper, 2·62 per cent.
Silver, 7 dwt. 2 grs. } per ton.
Gold, a trace

Yulgilbar.—About 1½ miles from Yulgilbar Cinnabar Mine. Copper ores in serpentine. Shaft, 35 feet. Carbonate ores reported as cut out at 25 feet. 3 tons 16 cwt. sent to Dapto yielded 12 per cent. of copper, 6 dwt. of gold, and 6 oz. silver per ton.

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COBAR MINING DISTRICT.

Canbelego Division.

Baalgammon Mine.—Stains of copper carbonate in gossan 3½ inches thick reported at this site. Company formed to prospect this occurrence on the Rookery Holding.

Bobadah Division.

Bobadah.—At the Overflow Mine copper ore occurs in one of the shafts (Booth's), associated with gold, silver, and lead. The lode strikes N. 30° W. in crushed porphyry; its chief value depends on the gold, silver, and lead contents, as the copper ores—carbonate and red oxide—are not very prominent.

Sullivan's lode, about one mile from Hillman's Tank, has been opened under aid from the Prospecting Vote, but no payable ore was discovered.

Aid also granted for site 6 miles south-west of Bobadah.

Copper ores occur about 1 mile N. of the Walker's Hill Homestead, where aid was also granted with unfavourable results. (*See* also Yellow Mountain and Recovery Copper Mines.)

Canbelego Division.

Bonnie Dundee Mine, parish Trenton, county Canbelego.—Originally opened for gold under aid recommended by Inspector Godfrey.[1]

No. 1 shaft 100 feet; No. 2, 300 feet. Strike of lode, N. 10 E., dip of copper veins S. 80° E. at about 65°.

Copper carbonates cut in No. 2 shaft at 230 feet. No. 1 shaft worked slightly for gold in oxidized zone.

At 230 feet about 14 feet of copper impregnated country struck, which dipped out of shaft in a few feet; a short crosscut here revealed the thickness stated. Hanging wall, or boundary of impregnation, not exposed on 29th October, 1907. Below the shaft passed into slate and schist country.

An average sample of this partially-enriched material chipped from 13 feet wide in shaft and crosscut, yielded:—

No. 07-7538—Gold, a trace Silver, 13 dwt. 1 grs.	per ton.	
Copper	2·12	per cent.
Iron	10·23	„
Sulphur	7·73	„
Silica	57·98	„

Boppy Mount.—Two miles by road W.S.W. from Boppy Mount Railway Station, parish Cohn, county Robinson. Quartz containing copper carbonate stains. Aided (P.B. $^{2}\frac{1}{0}\frac{2}{7}\frac{2}{2}$) to sink from 22 to 100 feet.

Budgery Copper Mine, M.Ls. 1, 2, 9, parish Hermitage, county Canbelego. Discovered in 1906 by R. A. Sorensen whilst further prospecting a site previously tested for gold.

Inspector Polkinghorne reported that the copper ore was struck in a cross-cut 55 feet E.S.E. from the bottom of a 218-feet shaft.

The Budgery lode consists of a large impregnated mass of magnesian slates much crushed and jointed, with frequent slippy "heads" or "slides."

Loose friable gossan extends down to a considerable depth, but is abruptly divided from the "black" ore (subsulphide of copper) by a smooth, flat heading. The frequency of these headings striking and dipping in all directions, evidences the results of some disturbing influence at no great distance.

[1] Further aid granted to sink from 306 to 406 feet. (P.B. 08-1882.)

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In the closely-adjoining South Budgery, and probably in Budgery itself, a fine crushed quartz-felsite (?) occurs. The magnesian slates, moreover, are highly contorted on a small scale, and probably also on a large.

Copper ores, notwithstanding extensive prospecting all round the proprietary boundary, have not been proved outside of the original discovery, except a few carbonate stains in the Budgery Reward North.

The enriched black ore, or partially altered sulphides, was of good quality, but, as expected, proved to be superficial, the grade depreciating by, at least, one-half in a few feet. The ore was mostly disposed of to the Great Cobar, Limited, at Lithgow, some little difficulty being encountered owing to excess of magnesia in the gangue.

Several applications failed to obtain an official statement of output to end of 1907, but the following have been noted. To the end of 1906—200 tons of ore had been disposed of for £1,821; the copper contents equalling 11·5 per cent. or 23 tons. (Ann. Rept., 1906, p. 45.)

As showing depreciation at lower levels, in August, 1907, it was announced in the Press that 23 tons 16 cwt. 1 qr. 5 lb. at the Great Cobar Works, Lithgow, yielded 5·86 per cent. As the latter grade could not be disposed of at a profit owing to cost of carriage, active mining practically ceased on exhaustion of the available richer ore, and efforts were confined to sinking a new shaft. The nature of the ore so far proved is likely to render direct smelting difficult.

As stated elsewhere, great excitement followed the discovery of Budgery, 108 applications for leases being received, and numerous companies floated; every possible variation of the original name being used as an inducement for investment.

The latest official statement of the position of the mine is contained in a report of the Directors of the Budgery Mines, N.L., submitted to the shareholders at the general meeting on the 13th September, 1907. The following extracts are from the mine manager's (Mr. J. R. Godfrey) report appended thereto for the half-year ending 31st August, 1907:—

"Previous work consisted of an engine shaft 218 feet deep; a main crosscut nearly due east from the shaft for 60 feet, where it cut the west wall of the deposit; a crosscut north-east for 105 feet, the first 30 feet being in good ore, the next 40 feet in lode matter too poor to be of any value, and then gradually dying out in country rock."

During 1907 engaged on developmental work, including deepening the main shaft to 283 feet; 1,920 tons of ore were raised, of which 797 tons of dressed ore were sold for £3,695.

Budgerygar Mine, M.L. 5, parish Trenton, county Canbelego.—Strong gossany outcrop in schist country.

The lode strikes N. 7° W., and underlays easterly, and consists of an impregnation highly pyritized, which at surface forms strong irony outcrop.

In the vertical shaft the impregnated belt was cut at 20 feet and passed through at 147 feet. From the 203-feet level a crosscut reached the footwall boundary of the mass in 62 feet, and was continued across it diagonally for 46 feet without reaching hanging-wall boundary. From this point a winze was down 45 feet (in October, 1907), where at bottom nearly pure iron pyrites was making.

The cross-cut at 203-feet level in the impregnated zone, passed through thin veins and finely disseminated pyrites—more or less black or sooty

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in parts owing to alteration of the little copper sulphide present—into subsulphide. Across the full thickness of this enriched mass a sample was carefully taken, which yielded the following results:—

No. 07-7540—Gold, a trace
Silver, 3 dwt. 6 grs.
Copper, 0·30 per cent.
} per ton.

A sample of the unaltered sulphides chipped across the full width at bottom of winze yielded:—

No. 07-7539—Copper, none detected.
Gold, a trace.
Silver, „

In June, 1908, more promising developments were reported in a new shaft, 270 feet deep, and a drive of 25 feet from that level.

Buppe Copper Lode, M.Ls. 53, 54, parish Buppe, county Mouramba, about 4 miles southerly from Mount Boppy Gold Mine, and between the Canbelego and Little Boppy Copper lodes.—Strike of lode north-west. Dip south-west at 43°.

Shafts 25 feet and 150 feet deep in M.L. 53, in October, 1907. New shaft cut lode at 75 feet, then followed on underlay to 150 feet from surface, under aid from Prospecting Vote.

Outcrop consists of rubbly quartz in quartzite and slate, with traces only of copper carbonates. Traces of gold only obtainable. Shaft in soft slate at 150 feet on hanging-wall side. Traces of carbonates in silicious material on footwall.

Canbelego.—Restdown Prospecting shaft, 15 miles from Canbelego—sunk under Government aid. Shaft 226 feet, in puggy kaolin; at junction of sedimentary rock, and intrusive quartz felsite.

In places along contact, kaolin converted into porcellanite is conspicuous, and sandstone into quartzite, arising from hydrothermal action following the intrusion. On surface superficial iron oxide occurs fairly solid, but silicious in places.

Shaft sunk 133 feet vertical, then on underlay to 226-feet level. Driven from this point 40 feet east in soft puggy clay, all picking ground. Pug ferruginous and manganiferous, with occasional kernels of crumbly silica, and quartzite.

No copper ores visible, but assays said to reveal its presence in small quantity—less than ½ per cent.

At a later date a sample from west crosscut in 23 feet, forwarded by the manager—showing copper sulphides partially enriched by subsulphide—yielded on assay:—

No. 07-7698—Copper, 3·02 per cent.
Gold, a trace.
Silver, 13 dwt. 1 gr.
} per ton.

Canbelego Copper Mine (late Saunders').—Portions 17, 18, 36, parish Buppe, county Mouramba; 4 miles south of Canbelego, and 7 from Boppy Mount Railway Station. Discovered by J. J. Saunders in August, 1901; who sank shafts 96 feet, 50 feet, 35 feet, and 38 feet deep, extending along lode for about 200 feet. Costeens expose a further distance of about 50 feet. Strike, N.E. vertical in slate. Average width of outcrop about 35 feet, including bands of country carrying small veins and strings of ore.

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COBAR MINING DISTRICT—*continued.*

Position in October, 1907:—Deepest shaft, 250 feet, which cut ore at 90 feet; water level, 158 feet.

Two faults slightly displace lode—at 78 feet to eastward, at 118 feet to north-east. Upper fault strikes N.W., and underlays S.W. at 45°; lower fault strikes N.E., and underlays N.W.

At the 155-feet level the lode has been driven on for about 50 feet. In north drive and cross-cut solid ferruginous ore exposed, containing considerable native copper. At 170 feet copper and iron pyrites occur in soft slate, signs of enrichment visible in the black powdery subsulphide coating chalcopyrite.

The gross weight of ore despatched by the discoverer totalled 63¼ tons, and returned an average of 28 per cent. of copper.

About 17 tons of dressed ore at mine of about 10 per cent. grade, seconds 2 to 3 per cent.

Canbelego District.—Canbelego West Mine, M.L. 21, parish Buppe, county Mouramba.—Prospecting shaft 135 feet deep, crosscut south-westerly for 30° at 116-feet level. A trace of copper only. Country, slate and schist, with quartz strings. Copper stains very slight in costeens further west. No indication of defined ore body.

Shango Mine, M.Ls. 14, 15, parish Buppe, county Mouramba.—Opened by Knight Bros. about 1902. Eight tons of copper ore from shallow open cut, reported to have yielded 15 per cent.

New shaft in country, 72 feet south of old shaft, and about 10 feet west of strike of lode; depth, 130 feet; no sign of ore. Strike N. 50° W.

Four and a half chains N. 15° W. of old workings, an 80 feet shaft has been sunk on a parallel vein. Both veins silicious.

Canbelego Queen, adjoining Canbelego North on the north-west, M.Ls. 37, 59, parish Buppe.—Three shafts 30 feet deep on M.L. 37. A few stains of copper carbonate in quartzite and slate. Cut out at 15 feet.

Canbelego North, M.Ls. 34, 35, parish Buppe, adjoining Canbelego Mine on north.—Prospecting for continuation of Canbelego lode. No ore; slate country. Shaft, 80 feet.

Bargin's Gold Lease (The Priests), parish Buppe.—Quartz and slate, with faint traces of copper carbonates in joints in crosscut on east side for a reported width of 20 feet. In west crosscut thin streaks of iron pyrites for 7 feet wide. This shows on surface as very ferruginous slate, with thin honeycombed bands after pyrites.

Quartz abundant; reported to assay at best about 1 dwt. 3 grs. per ton. Joints glazed with thin films of black iron oxide, imparting a metalliferous look to outcrop.

Shaft down 115 feet, and cross-cut 55 feet at 100-feet level.

North Shango, at N.E. corner, M.L. 16, parish Buppe, county Mouramba, about 90 feet from corner of lease.—Prospecting—by shaft—for supposed continuation of Canbelego lode. Shaft in country; no ore.

Canbelego Peak, parish Buppe, county Mouramba.—Shaft 174 feet deep, crosscutting west to brecciated belt under Peak. Country, quartz pebble conglomerate and quartzite, with bands of ferruginous slate. Shaft sunk in

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latter, which shows faint traces of copper carbonate in cleavage. A little gold is reported in the breccia on surface about 70 feet west. If not payable in oxidized condition, unlikely to be in pyritic.

Canbelego West, parish Buppe, county Mouramba.—Shaft in schist country, with quartz strings; stains of copper carbonates in outcrop.

Shaft, 135 feet; crosscut at 116 feet for a distance of 30 feet. Formation 6 ft. 6 in. wide, with traces of copper only.

Cobar Division.

Cobar-Chesney Gold and Copper Mine, held by the Great Cobar, Limited.—This property consists of Mineral Leases 12, 19, 23, 44, 58, 61, 68, 106, and 107, embracing an area of 98 acres 0 roods 38 perches, also a freehold of 100 acres.

Originally worked as a gold-mine—the first in the field—the Cobar-Chesney afterwards assumed considerable importance as a copper proposition. A large quantity of the auriferous impregnated slate from the oxidised zone was treated by battery and amalgamation for an average yield approximating to 7 dwt. of gold per ton. The outcrop betrayed no evidence of the copper ores below; at 150 feet carbonate stainings became very marked. Sulphides began to show about 250 feet from the surface, the chalcopyrite being coated with melaconite (black oxide).

During a visit in 1898, when the main shaft was down 460 feet, a cross-cut at 360 feet through the lode revealed a thickness of 40 feet. A level had been driven 550 feet along the lode, from which two other cross-cuts intersected the lode, showing its width to be persistent throughout the distance proved. The assay values, obtained by chipping across the face of each cross-cut through the lode, were as follows:—

Cross-cut 200 feet south of main shaft—average yield, 5 per cent. copper.
" (main) from shaft—average yield, 3 per cent. copper.
" 350 feet north of shaft—average yield, 8 per cent. copper.

The gold contents approximated from 2½ dwt. to 3 dwt. per ton.

Further indication of the value of the ores in the Cobar Chesney lode is afforded by the following assay determination quoted by Mr. T. Longworth, in the prospectus of the Cobar Chesney Company, 1897, p. 16:—

"NOTE.—All the assays are fire assays, and should be fully worked up to.

Sample.	Copper, Fire Assay.	Corrected to Chemical Assay.	Gold, per ton.
	per cent.	per cent.	dwt. grs.
No. 1—Carbonate from No. 3 shaft, 155 feet deep.....	2½	3·8	3 6
No. 2— " " " 214 "	3	4·3	3 6
No. 3—Sulphides " " 275 "	2½	3·8	3 6
No. 4— " " No. 1 shaft, 330 feet deep, south drive.	4½	5·8	a trace.
No. 5—Sulphides from No. 1 shaft, 360 feet cross-cut..	3	4·3	3 6
No. 6—Sulphides as mined from the whole of the lode in Nos. 1 and 3 shafts.	3	4·3	3 6

The assay value of the ore as shown in these samples is about 1 per cent. lower in copper, and almost identical in gold with the ore at present mined and treated at the Great Cobar Copper-mine.—THOMAS LONGWORTH, Manager, Great Cobar Copper-mine, Cobar, 29th October, 1897."

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Cobar Chesney Copper and Gold Mine.

(Main Shaft.)

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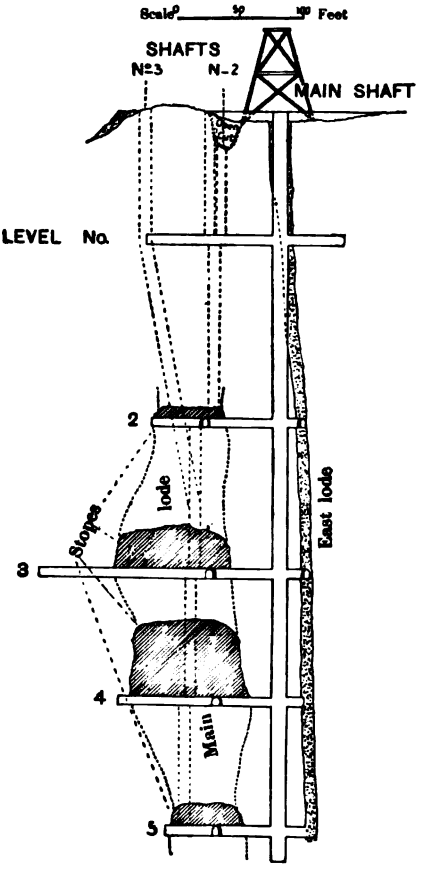
COBAR CHESNEY MINE

CROSS SECTION



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The carbonate ore between the 150-feet and 250-feet levels was estimated by the same authority to average about 6 per cent. of copper; and the sulphides about 20 per cent. of iron.

The sulphides occur investing slate and quartz, a small proportion of direct smelting ore could be hand-picked.

Considerable interest attached at one time to prospecting operations in the Burrabungie Lease, on the south boundary of the Cobar-Chesney, where an outcrop of ferric oxide occurs (west of the Chesney main line). A cross-cut at the 200-feet level to the west under this outcrop intersected a band of iron pyrites about 10 feet thick, part solid and part mixed with the slate country; it betrays little evidence of associated copper pyrites.

In 1901 about 4,500 tons of Chesney ore were treated in the Great Cobar smelters for a return of 3 per cent. copper, and about 1 dwt. of gold per ton. (Ann. Rept., 1901, p. 53.)

In 1904, the mine was purchased by the Great Cobar Syndicate, and has since been worked in connection with the Great Cobar Mine. About 27 per cent. of the smelting charge being from the former, the silicious nature of its matrix acting as a flux for the basic ore of the Cobar lode.

The output of the Chesney Mine from 1904 to August, 1906, being as follows:—

1904	16,885·11 tons	Supplied by Dr. Richard Read, Managing Director, Great Cobar Syndicate.
1905	45,310·73 „	
1906	26,613·385 „	
Total ...	88,809·225 „	

Position in October, 1907.—Greatest depth of proving, 700 feet; greatest length, 820 feet; greatest width, 92 feet; average, 35 to 40 feet. Narrows to south end.

Average copper contents about 3 per cent.; gold, 15 to 24 grs.; and silver, 1 to 2 oz. per ton (smelting returns.)

A short gold shoot on the north end has been followed down like a pipe from the surface, 3-oz. stone being procurable from it.

About 75 feet east of the main lode, a 4-feet vein was worked to No. 1 level for gold. It has since been opened by cross-cut from a lower level, where its gold value is estimated at 6 dwt. per ton, with fair copper value also.

Water was met at 360 feet, equal to about 50,000 gallons per day. At 700 feet, a fresh flow was struck in shaft, equal to 300,000 gallons per day; now making about 250,000, and standing 85 feet below No. 5 level, present pumps incapable of reducing it lower.

The ore from the Chesney lode is broken to about 6 inch gauge, then conveyed by travelling belt to ore hopper for trucking. Belt travels about 30 feet per minute, boys on either side pick out portion of the worthless material whilst ore is in transit. Fines go to furnace direct.

The Chesney chalcopyrite is of high grade when clean. It occurs disseminated in the slate and quartzite, and in veins from a mere thread up to 2 or 3 inches in thickness.

Cobar Copper, Limited.—The Cobar Copper, Limited, has secured the well-known Mount Pleasant and Young Australia Mines on the metalliferous belt of impregnated slate and quartzite, which, with the exception of one

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block, has been more or less profitably worked between the Cobar-Chesney and Occidental Mines. It strikes about N. 15° to N. 20° W., and varies in thickness up to 300 feet.

The Mount Pleasant and Young Australia, in common with the others along this line, were first entirely worked as gold propositions. As operations extended below the sphere of oxidation and leaching, copper gradually became sufficiently pronounced to seriously impair the efficiency of the economic cyanidation gold extraction process.

The difficulty was moreover enhanced by the extreme diffusion of the copper in the silicious rocks forming the lode.

In the Mount Pleasant lower levels more concentrated bodies of copper ore occurred, from two of which a considerable quantity of smelting ore was obtained in 1900 and 1901, for treatment in the Great Cobar smelters.

Copper sulphide appeared at the 160-feet level in the Young Australia section, but there is no record of any extraction, though the shaft reached 277 feet.

Position in October, 1907.—The new company was confining its operations to deepening the main shaft in the Mount Pleasant section from 340 feet to 530 feet, when, it is proposed, to cross-cut the belt in the permanent sulphide zone. The previous developments at the 150-feet and 215-feet levels disclosed three main metalliferous bands in a width of 300 feet. The intermediate country, in addition to a general dissemination of metallic ores in infinitesimal proportions, contains thin streaks of more pronounced value notably in the shaft at 340 feet.

The East lode has a width of about 4 feet, it consists largely of manganiferous quartz, with patches of fair grade copper ores. It lies 160 feet east of the main shaft, and has been stoped between the 215 and 150 feet levels, and proved in a winze below the latter to a reported depth of 70 feet. Between 150 feet and the surface it is unstoped. Sixty-eight feet west of the shaft, at both levels, a considerable width of auriferous ore has been stoped, between the levels, and from the upper to the open surface quarry, in which gold was first obtained. Below the 215-feet level this band has not yet been followed.

Eighty feet west of the Middle lode is the furthest western proving known as the West Copper lode, which has a width of about 8 feet. This band has been worked between the levels and sunk on 40 feet below the 215 feet.

From the East and West lodes the copper ores were obtained for the Cobar smelters. The gold ore from the open cut and lower stopes is reported to have yielded about 6 dwt. per ton.

C.S.A. Mine.—M.L. 4, parish Kaloogleguy, county Robinson, about 8 miles northerly from Cobar.—A well-known large gossany formation, which had received intermittent attention during a long period extending back to the early days of the Cobar Copper Mine, but which was not tested to water level until 1906.

Inspector D. Milne reported (P.B. $\frac{6}{1908}$) that several shafts had been sunk on different veins of copper ore, and in the large gossan lode a shaft had been sunk 250 feet. The lode at this level was very wide, and carried a little gold all through, with occasional veins of lead carbonate, in gossan.

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Aid was granted to sink to 350 feet and to cross-cut 50 feet at that level. After carrying the shaft down 332 feet operations were abandoned no payable ore being discovered at that depth in the still persistent porous gossan.

Inspector J. Polkinghorne recommended (P.B. $\frac{2222}{05}$) further aid, which was granted to deepen the shaft to 482 feet, and to cross-cut 75 feet east and 50 feet west. Water-level was reached at 457 feet; and a cross-cut started west a few feet above it, in which rich carbonate of lead was struck; the redeposited, concentrated result of 450 feet of leaching. Below the water level the change to lean sulphides of iron, lead, and copper, was sudden.

The company, formed as a result of the rich lead strike, is now sinking the new main shaft well below the water level, for the purpose of testing the sulphide zone, the success of the mine depending upon the existence of sufficient copper sulphide to form matte in blast-furnace treatment. Until this is proved its future is problematical. In the north end of the property stains of copper carbonates are visible in the old shaft tips, but levels driven at 450 feet to these points have not been encouraging. In the bores to a depth of 150 feet below the 450-feet level fair copper values prevailed for a few feet, but soon diminished to unworkable proportions. In the drive from the main shaft to the lode at 450 feet, thin plates of native copper were encountered in a few feet of country.

In *Gardiner's Block* on south end, better grade copper ore has been cut in a winze from the 400-feet level.

Inspector J. Polkinghorne states (Ann. Rept., 1907, p. 90) that 80 tons of ore were raised from this mine during 1907, of which 47 tons were treated for a yield of 5 tons of copper, equal to 10·6 per cent.

J. Gainford & Co. state that 50 tons sent to Swansea yielded 11·1 per cent. of copper, a trace of gold, and a small percentage of silver, and gave a return of £5 19s. 10d. per ton. Traces of copper ore show very faintly in Block 19.

The following notes were extracted from a report on the Cobar Mining Field furnished by the Writer in 1906:—In the mines—other than the Great Cobar Copper—knowledge of the conditions obtaining in the lowest working levels is a *sine qua non* for intelligent report; for below a critical depth complete revolution in the methods of metal extraction will be enforced by changing conditions of mineral association. The ore reserves above this level also determine duration of present methods, and the urgency of timely decision as to future procedure. The opinion formed of the prospects of the Cobar Field whilst investigating the copper industry in 1899 has been strengthened and confirmed by subsequent recorded developments. At that time the Cobar Gold-mines, Occidental, Mount Pleasant, Young Australia, Great Western, and Peak Mines were producing free milling and cyaniding auriferous lodestuff, but even then were betraying signs of copper admixtures with increasing depth—presaging the stage reached in the Cobar-Chesney Mine, where free milling had given place to cupriferous lodestuff, unamenable to such treatment, and yet too lean for direct smelting as copper ore. The change entailing in the oxidised zone expensive leaching before cyanidation, and costly mechanical concentration in the unoxidised, in a region of low rainfall and slight catchment.

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To a depth of about 150 to 200 feet, free milling and cheap cyanide extraction processes are possible and profitable; below that level for a hundred feet or more the lodestuff is stained with oxidised copper ores; then, after an intermediate stage of partial oxidation, the permanent copper sulphide zone is reached.

Mechanical concentration offers little prospect of successful achievement in the oxidised lodestuff. The experience on lean carbonates at Girilambone and Mount Hope was not encouraging, the difference between copper-stained and unstained lode material is too slight for gravity separation. In this zone, however, natural concentration—by secondary enrichment—may be expected to furnish limited bunches of direct smelting ore, bearing but little proportion, however, to the bulk of the lode.

A chemical process, viz.:—Leaching with sulphuric acid prepared locally from the sulphide ores, is possible, but impracticable—so far as present indications go—for any of the mines mentioned, owing to absence of solid sulphides suitable for roasting direct, and excessive cost of concentration for this purpose.

To establish leaching vats with imported sulphuric acid, as was recently done by the purchasers of the Cobar-Chesney tailings, would not, in the Writer's opinion, pay on a large scale, nor would it obviate the necessary cost of calcining the lean sulphides preparatory to leaching.

The possibility of smelting the cupriferous ores from the Fort Bourke (Cobar Gold-mine) and Chesney-Occidental lines of lode is, so far as indications go, discounted by the absence of sufficiently concentrated iron sulphides and the nature of the matrix. Judging by the Cobar-Chesney sulphides and the concentration products therefrom, the clean sulphides are comparatively rich in copper and low in iron. The matrix of these ores, consisting of slate, quartzite and quartz, requires a large proportion of iron for fluxing. Failing command of cheap and abundant supply, the mines along these lodes cannot hope to establish independent smelting plants on a profitable basis.

The disabilities under which they labour throw into strong relief the possibilities and potentialities of the immense solid pyritic resources of the Great Cobar Copper lode. This kindly fluxing base, in the Writer's view, is the key to the situation, and must, if persistently basic, in the near future exert controlling influence, unless a radical change is discovered in yet untested levels in the other mines. The urgency of deep testing, preferably by diamond drilling, is therefore apparent.

The cogency of the opinion expressed in 1899 is quadrupled in 1905. The large fluxing base at the command of the Cobar Company opens up the most extensive problem of the field. Large as is the scale on which operations are now conducted, they are capable of still further development. However unpopular the idea of huge trusts and combines may be, there is no question that only under such conditions of consolidation will some of the extensive low-grade cupriferous gold and silver deposits of the vicinity be turned to best account. For though at present the Cobar-Chesney Mine is the only other of the Cobar group that has developed copper ores of commercial importance, there is every reason to anticipate, at all events, an amount of copper ore in the lower levels of the others sufficient to render unprofitable any method of extraction other than smelting in the way indicated.

Consideration of the present condition and future prospects of the copper-mining industry of this State establishes clear-cut conviction of the advantages

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of a closer union or concentration of interests. Instead of vainly contending with refractory ores, combination with those requiring just such economic admixtures in the reducing and refining processes would prevent one section struggling with costly experiments, the other using perforce valueless fluxes. Cobar-Chesney and Girilambone illustrate one division; Great Cobar, Nymagee, and the refining plants, at Lithgow, the other.

If community of interests and reduced railway freights could bring these divisions into touch, reciprocal advantage would accrue to both State and industry.

The future possibilities of the extensive pyritic lode at Captain's Flat, under some such reciprocal provision, loom largely ahead as affording the means of treating refractory auriferous and argentiferous copper ores, whilst adding to them its own small quota of these metals, and at the same time it is to be hoped, utilising its valuable sulphur contents.

The Cobar-Chesney Mine, after vain expenditure of capital and labour fighting the difficulties of a separate existance after the free-milling ores were extracted, was absorbed in the operations of the Great Cobar Copper-mining Syndicate.

Unless a vital change, as yet unindicated, occurs in the constitution of the lodestuff at lower levels yet unreached in the other mines under consideration, a similar fate appears to await them, *providing* always that the pyritic resources of the Great Cobar copper lode persist undiminished in solidity, and comparative freedom from silica.

Each of the mines mentioned has already, or will shortly, encounter the same difficulties that confronted the Cobar-Chesney, viz.—increasing copper contents preventing cheap gold extraction, yet insufficient for direct smelting. The fundamental difference between the cupriferous ores of these mines so far as proved, and that of the Great Cobar copper lode, lies—as already stated—in the nature of the matrix. Even if their copper contents were doubled, they would still be unsmeltable, save at considerable cost for concentration and fluxing.

The massive sulphides of the Great Cobar copper lode consist of magnetic and ordinary pyrite and copper pyrite (the latter itself a mixture of copper and iron sulphides), with a comparatively low percentage of silica. The advantages of a large body of this composition are:—(*a*) Its suitability for pyritic or partial pyritic smelting, whereby an enormous saving is effected in cost of fuel as compared with ordinary blast or reverberatory methods; (*b*) saving of whole or partial cost of initial roasting; and (*c*) production of clean and more silicious slags. The latter, an object of great importance at Cobar, where gold (and silver) ores are required to be worked (as flux) with the copper, for by keeping the slags silicious (and therefore fluid) the precious metals may be concentrated with the copper to any reasonable extent.

Silica is necessary in the furnace charge to combine with the abundant iron of the sulphides to form a fluid silicate of iron slag which may be floated off. The low-grade refractory ores of the neighbouring mines are just what is requisite for fluxing requirements. A silicious schist or slate, according to Dr. Peters, junr.,[1] is preferable to pure silica (quartz) in matte roasting, and doubtless also in smelting. The advantage to a smelting company of command of suitable flux, having of itself intrinsic value, is great, whilst an equivalent benefit should be derived by suppliers.

[1] Modern Copper Smelting, 5th ed., 1892, p. 271.

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The appearance of copper ores in the lower levels of the principal gold-mines at Cobar induced a belief in the minds of some, that the lodes in them were at one time connected on a continuous strike with the Great Cobar copper lode, and subsequently disconnected by faulting. This idea, however, conflicts with readily discernible physical and geological facts. At least four distinct lodes are traceable on true and undisturbed courses parallel to each other. The absence of disturbance, or of intrusion, is a marked feature of the field. Inspector Milne informed the Writer that there was underground evidence of an eastern movement at the south end of the Great Cobar copper workings, in what was originally known as the South Cobar. But he is not aware of further evidence in the other lodes.

The Great Cobar copper lode occupies one vertical plane; the Fort Bourke or Cobar Gold-mines another; the Cobar-Chesney, Phœnix, Mount Pleasant, Young Australian, Great Western, and Occidental another; and the Peaks still another, more remote.

The great disparity in horizontal distance between the different parallel strikes of those lodes would necessitate separate faultings, of which there is no evidence.

The absence of indication in the outcrops of copper ores encountered at a depth, is especially likely in those instances where, as in the gold-mines of Cobar, the ores are leanly and evenly disseminated through a matrix consisting of slate and quartzitic country.

On the other hand, where large bodies of concentrated copper and iron sulphides were originally exposed in or near the outcrop, as at the Cobar Copper-mine and other big lodes, though the copper, from its greater solubility, may be more or less completely removed, the resulting insoluble iron oxide remains to indicate the pyritic mass beneath. In none of the gold-mines at Cobar were there any surface indications of massive metalliferous bodies beneath, excepting in the disappointing Burrabungie section, where a western outcrop of iron oxide betokened concentration, but its lower levels did not realise expectations.

The presence of copper ores between 150 to 200 feet in the present working gold-mines open the questions of free milling and cyaniding reserves still in view above these levels, upon which depend the duration of operations under existing methods, and the wisdom of establishing similar processes where quantity warrants.

Where supply justifies the latter, the experience of the Occidental and Cobar Gold-mines proves that only on a large scale can such low-grade deposits be attacked. To quote Inspector J. R. Godfrey:—"To work them in a small way is worse than useless, because it not only does not pay, but destroys the value of the mine by removing the better class ore, and thus rendering the whole less amenable to profitable treatment."

Of the Occidental Mine, the same officer wrote:—"The success of this mine is a strong argument in favour of economic handling on a very large scale. When the mine was worked with a small mill, it only paid to search for and treat the rich patches, now that they have a large mill, supplemented by a large cyanide plant, they can treat all the lodestuff and pay dividends, and the success of the mine is now about equally due to cheap mining on a large scale and the saving of the gold by the cyanide process."—(Ann. Rept., 1900, p. 102.)

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Cobar Mining District—*continued.*

The Cobar Gold-mine, late Fort Bourke, had a successful campaign with free milling stone above the 200-feet level.

Inspector J. Polkinghorne reported—"that about all the free milling ore has now been extracted from the Cobar Gold-mine. At the No. 3, or 250-feet level, the lode has been driven on about 500 feet in length, and a cross-cut put in, which proves the lode to be upwards of 80 feet in width, and of fair gold value, but the presence of copper makes the ore difficult to treat. Pending the erection of a different plant work will be confined to sinking and driving."—(Ann. Rept., 1904, p. 89.)

The following statement of output and yield has been compiled from published reports duly specified. The figures are not to be regarded as complete, but simply as an indication of value and proportional yield from crude ore, tailings, and slimes. The exceedingly fine physical character of the gold in the leached zone doubtless accounts for the high recovery from slimes. The lessening yield from the latter in the latest returns probably indicates the copper influence as well as depreciation.

From the well-known precipitating action of the metallic sulphides, it is reasonable to anticipate secondary gold enrichment about the zone of partial oxidation.

Authority.	Date.	Tonnage of Crude Ore (Amalgamation).	Tonnage of Tailings (Cyanide).	Tonnage of Slimes (Cyanide).	Yield, Gold.
	1902.				oz.
Australian Mining Standard.	6 Feb. (for Dec., 1901).	7,302	.....	.....	539
		.....	1,941		1,258
,,	6 Mar. (for Jan., 1902).	6,514	.....	.....	622
		.....	3,939	 2,679	1,962
		.....	.....		
	1903.	11,382	.....	.....	1,317
,, ...	26 Feb.	.....	6,985	 4,932	3,535
		.....	.....		
	1904.	6,473	.....	.....	711
,, ...	5 May	.....	4,153	.....	1,331
		.....	.....	2,124	1,002
		6,380	.....	.....	561
,, ...	2 June	.....	3,995	.....	955
		.....	.....	2,187	1,054
		6,398	.....	.....	720
,, ...	30 ,,	.....	4,362	.....	1,172
		.....	.....	2,652	1,353
		5,170	.....	.....	646
,, ...	28 July	.....	3,466	.....	736
		.....	.....	2,262	1,000
		4,850	.....	.....	567
,, ...	1 Sept.	.....	3,196	.....	726
		.....	.....	2,262	1,027

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COBAR MINING DISTRICT—*continued*.

Authority.	Date.	Tonnage of Crude Ore (Amalgamation).	Tonnage of Tailings (Cyanide).	Tonnage of Slimes (Cyanide).	Yield, Gold.
					oz.
Australian Mining Standard.	1904. 29 Sept.	5,455	.....	.....	462
		.....	3,565	.....	726
		.....	.....	1,696	849
,, ...	3 Nov.	4,255	.....	.....	426
		.....	2,873	.....	492
		.....	.....	1,125	450
,, ...	Dec.	2,700	.....	.....	338
		.....	1,753	.....	415
		.....	.....	1,125	465
,, ...	1905. 26 Jan.	1,689	.....	.....	239
		.....	1,624	.....	304
		.....	.....	870	217
,, ...	9 Mar.	1,472	.....	.....	389
		.....	1,810	.....	492
		.....	.....	889	213

Representing a total of 70,109 tons of ledestuff, and an extraction of 8 dwt. 6·3 grs. per ton.

The total output from 1897 to February, 1905 (inclusive), as supplied by the company, amounts to 113,599 oz., of a value of £351,101.

The bulk of the output has been cheaply won by means of an extensive open cut, in which quarrying on a large scale was possible under most favourable conditions.

The Cobar-Chesney lode extends, as before stated, through the Phœnix, Mount Pleasant, Young Australian, Great Western, and Occidental Mines. It is a very strong impregnated body of country, averaging over 30 feet in width. In the Cobar-Chesney, at the extreme north end, it has been exposed in the workings for a length of over 800 feet, with an average width of 35 feet to 40 feet. In the Occidental, at the extreme south end, it proved equally strong in the extensive open-cut workings, which reached a depth of 130 feet.

Only in these two mines has the full width of the lode been attacked. The intermediate mines have confined operations to limited patches of richer stone, instead of utilising the whole on a scale commensurate with its extent.

Thus, in the Great Western Mine, to whose southern boundary the open-cut workings of the Occidental have been extended, the method of exploitation called forth the following strong statements from Inspectors Godfrey and Schloesser:—"This mine has been alternately at work and under suspension throughout the year, but at no time has it been worked on an extensive scale, and all the work has been confined to a small reef on the east side of the main lode. This main lode is the same as that worked so successfully a few hundred feet away by the Occidental Company, and it seems incomprehensible how a mine should leave its main ore-body unproven and undeveloped when the very next mine is paying dividends." (Ann. Rept., 1900, p. 102.)

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Inspector Schloesser stated that "the Great Western has proved the extension of the Occidental ores into its ground by a crosscut to the west from the 400-feet level. A large amount of dead work is, however, necessary before such low-grade material can be worked by underground stopes on anything like an adequate scale. After being idle for eleven and a half months the mine is now in the hands of tributers, who can hardly be expected to improve the mine.

"Possessing exactly the same ore as the Occidental is now profitably exploiting, and, in addition, possessing the Albion lode, that was in the past highly payable, there seems no reason why, if worked on a large scale, this mine should not give profitable returns." (*Ibid.*, 1902, p. 79.)

It is difficult to arrive at the output of this mine to date. For long periods practically little was done save following the rich shoot in the Albion lode. The first available record shows a yield of 106 oz. from 180 tons; depth 40 feet, lode 4 feet thick. (Ann. Rept., 1893, p. 65.)

In 1895 a record of 951 oz. from 870 tons (*ibid.*, 1895, p. 29), and 1,063 oz. from 919 tons in 1896 (*ibid.*, 1896, p. 36), equivalent to about 21½ dwt. per ton. Patches of even richer stone were obtained where evidence of leaching and redeposition in the metallic state was afforded by leafy films of metallic copper intercalated in the laminæ of the ferruginous slate forming the lodestuff. This class of ore was sorted from the battery stuff and despatched to the Dapto Smelting Works. The following returns from this ore were taken from the *Australian Mining Standard* of 11th August, 1898, and a later issue:—

9 tons 15 cwt. yielded—Gold, 5 oz. 11 dwt. 8 grs. per ton; copper, 3·1 per cent.
14 tons 13 cwt. ,, ,, 4 oz. 2 dwt. 3 grs. ,, ,, 2·1 ,,

There appears to have been no output from this mine during 1901–04. It was subsequently purchased by the Occidental Company.

Immediately adjoining the Great Western on the north is the Young Australian Mine, in which mining also has been confined to exploiting rich patches only. Very meagre particulars only are available of this mine in published reports. In 1896 a yield of 1,003 oz. was reported from 1,900 tons (Annual Report, Department of Mines, 1896, p. 36), a fraction over 10 dwt. 13 grs. per ton. The only other record is 431 oz. from an unknown quantity of lodestuff. (*Ibid.*, 1901.)

The oxidised stone is comparatively free from copper, cyanidation of the tailings being successfully carried on. It was estimated that about 27 per cent. of the gold contents was extracted in the stamper battery, and 90 per cent. of the remainder by cyanidation, additional evidence of the importance of the latter process, and the seriousness of any obstacle, such as slight copper contamination, vitiating its application. A 15-head stamper battery and small cyanide plant constituted the treatment plant.

The Mount Pleasant Mine adjoins the Young Australian on the north. Cupriferous lodestuff was struck at 160 feet from the surface, consisting of carbonates, red oxide, and grey sulphide. At 180 feet the change to yellow sulphides began.

Published records furnish very scant information concerning operations in this mine. Such as are available indicate copper as the chief product. In 1895, 469 tons of oxidised lodestuff appear to have been treated for a return of 87 oz. of gold, equivalent to 3·7 dwt. per ton. (Ann. Rept., 1895, p. 29.)

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The first record of copper output appears to have been 10 tons raised by tributers, which returned 27 per cent. at Cockle Creek Smelting Works. (*Australian Mining Standard*, 22nd December, 1898.)

In 1899 Inspector Milne reported that, after long suspension, this mine was opened under tribute by the Cobar Mining Syndicate, some rich bunches of carbonate and grey ore being obtained. (Ann. Rept., 1899, p. 100.)

In the following year Inspector Godfrey reported that "twenty men were employed under the tribute with satisfactory results on a small scale, no large bodies of copper ore being discovered, but occasional rich small patches are found." (Ann. Rept., 1900, p. 102.)

In August of the same year an output of 510 tons of ore, yielding 28 tons 15 cwt. of copper, is recorded. (*Australian Mining Standard*, 9th August, 1900.)

In 1901, Inspector Schloesser reported that this mine had been steadily working some rich pockets of carbonates and sulphides. (Ann. Rept., 1901, p. 89.)

In August, 1902, the tributers are reported to have extracted 2,353 tons of ore from Mount Pleasant, for a yield of 150 tons of copper (*Australian Mining Standard*, 7th August, 1902), equivalent to 6·37 per cent.

The Mount Pleasant and Young Australia are now held by the Cobar Copper Company, Limited, which see.

The Phœnix (late Burrabungie) Mine occurs between Mount Pleasant and Cobar-Chesney. So far there has been no output recorded either of gold or copper ore. A shaft was sunk 200 feet, close to the south boundary of the Chesney. A crosscut west at 200 feet undercut a ferric oxide outcrop, passing through about 10 feet of iron pyrites, part solid, part mixed with slate, in which but little copper sulphide occurs. Above the sulphide level stains of copper are visible in the rotten slate country. A crosscut from the Chesney main shaft across the strike of the Burrabungie pyritic band failed to encounter it, pointing to its probable existence as an isolated segregation. A crosscut to the east cut a mullocky lode with films of native copper 30 feet from the main shaft.

The principal developments on this lode have taken place at the extreme north and south ends, viz., in the Cobar-Chesney and Occidental Mines—in the former by underground stoping, in the latter by open cut. The absorption of the Cobar-Chesney by the Proprietary controlling the great copper lode removes it from the sphere of speculation as to future proceedings. Special interest, however, attaches to this portion of the lode as being the site of the first (practical) gold discovery on the field, and the instigation of the great industry subsequently developed.

The presence of gold in the oxidised ores, and in the metallic product of the Great Cobar Copper-mine had long been noted, though, strange to say, no effort was made to realise its value until the Cobar Mining Syndicate began operations in 1893–4, notwithstanding the results of an assay in the Departmental Laboratory being made known in 1881, viz., 2 oz. 12 dwt. 4 grs. gold, and 1 oz. 5 dwt. silver per ton, from borings through several ingots of export copper.

Gold was discovered in the Cobar-Chesney in 1887. Two tons from the outcrop, treated at the Sydney Mint, yielded a little over 4½ oz. per ton. In the following year 28 tons were forwarded to Victoria. Fourteen tons

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under ordinary battery treatment yielded 1 oz. 17 dwt. per ton. The other 14 tons, under chlorination, yielded 2 oz. 3 dwt. 15 grs. per ton. A further test of 31½ tons yielded about 2¼ oz. per ton.

In 1889, 2,436 tons yielded 796 oz. 12 dwt. from a lode 4 to 25 feet in width (Ann. Rept., 1889, p. 18), equivalent to about 6½ dwt. per ton.

In 1890, 880 tons for 586 oz. (*Ibid.*, 1890, p. 20).

In 1891 and 1892 no returns.

In 1893, 328 tons for 222 oz. (*Ibid.*, 1893, p. 65.)

In 1894, 1,895 tons for 1,019 oz. (*Ibid.*, 1894, p. 32.)

Disregarding the small parcels of rich stone, the bulk output, so far as recorded, averaged 9·47 dwt. per ton.

The copper value of the enriched portion of the lode may be gauged from the output recorded in 1901, when 4,500 tons treated in the Cobar smelters yielded 135 tons of copper, equivalent to 3 per cent.

Of the concentrates produced during the Cobar-Chesney Company's experiments with concentrating plants, 91 tons 5 cwt. 3 qrs. 16 lb. at the Cockle Creek Works returned £669 5s. 9d., including 26s. 3d. per ton for gold. (*Australian Mining Standard*, 8th March, 1900.)

The outcrop was free from copper. At 150 feet it began to show freely in carbonate form, and as sulphides at about 250 feet. The presence of copper gradually prevented profitable gold extraction by ordinary milling practices. The accumulated cupriferous tailings were eventually leached with sulphuric acid and cyanided.

So far as the lode has been pierced—over 700 feet—it has given no sign of concentrated ore bodies, the copper and iron sulphides being disseminated through the slate and quartz matrix.

The Occidental Mine has had the longest sustained milling career of any on the field. Unfortunately the total output is not obtainable. The following returns, however, give an idea of the value of stone extracted:—

Beginning with a small milling plant, successful headway was not achieved until it was increased to fifty stamps, with the necessary complement of cyanide vats. With the lode about 70 feet in width, in which quarrying was possible to a depth of 150 feet, mining costs were reduced to a minimum. On the large scale on which this mine has been worked, an average extraction of 4·4 dwt. per ton in the upper levels, and 3·19 dwt. in the lower, has been profitable. The copper contamination problem now, however, confronts the near future. Inspector Polkinghorne states that the estimated quantity of ore in sight—presumably free-milling ore—at the end of 1904, was 80,000 tons, and expresses an opinion that the appearance of the lode at 340 feet in the shaft betokens future development into a copper lode. (Annual Report, Department of Mines, 1904, p. 89.) Copper, however, makes its appearance, and will be troublesome below about 250 feet.

The following returns are compiled from the Annual Reports of the Department of Mines, for the years 1889 to 1896, viz.:—29,111 tons for a yield of 6,464½ oz., equivalent to an extraction of 4·4 dwt. of gold per ton.

The gold output recorded in the *Australian Mining Standard* from March, 1900, to February, 1905, totals 14,451 oz., but the tonnage is only given in three issues.

The output for the three years ending December, 1903, is reported as 102,512 tons for a yield of 16,375 oz., equivalent to an extraction of 3·19 dwt. per ton.

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Of the Peak lode few particulars are available. The discovery of gold at this point followed very closely that of the Chesney. Some rich stone has been extracted, but operations have been of an intermittent character, owing to the irregular and patchy nature of the gold shoots.

The presence of silver in payable proportion in some of the lodestuff is a marked feature, inasmuch as this metal is not prominent in the neighbouring lodes. Some of the rotten slate lodestuff, containing chloride of silver equal to about 30 oz. per ton, was used for fluxing purposes in the Cobar copper smelters.

The gold yield from the Peak, so far as known, averaged a little over 1 oz. per ton for an output of over 8,000 tons.

Cobar District.—In the Central Prospecting Shaft, about 10 miles from Cobar, and 3 from Queen Bee Mine, infinitesimal traces of copper occur in quartz. No value disclosed in over 300 feet of sinking.

Cobar Tharsis, about one mile N. of Cobar, and apparently on the strike of the Fort Bourke (Cobar Gold-mines) and East Cobar lode, viz., N. 10° to N. 15° W. Known also as the Ivanhoe and East Cobar Copper-mine Extended.

Under the latter title aid was granted (P.B. $\frac{21}{0}\frac{14}{5}\frac{21}{}$) to drive along the lode 100 feet, and to cross-cut east 20 feet, at the 307-feet level.

Later the property was disposed of to the Cobar Tharsis Company, N.L.

Shaft deepened to 350 feet in November, 1906, after which work was suspended. No payable ore was disclosed. The little raised was of a very poor, silicious nature.

Tindary Station.—Raymond and party's prospecting site, 27 miles from Cobar, and 1½ miles east of Cobar-Bourke road, parish Ramsay, county Robinson, Inspector Polkinghorne reported (P.B. $\frac{12}{0}\frac{8}{5}\frac{21}{}$):—Quartz reef with copper stains at 25 feet. Aided to sink 52-feet shaft to 202 feet, and to drive 50 feet along reef.

At 163 feet prospects reported as improving. No further record.

Mallee Tank and Conqueror Prospecting Shafts.—Limestone was struck in each of these; a sample from the latter gave the following composition on assay:—

No. 07-7431—Calcium carbonate	97·10	per cent.
Ferric oxide and alumina	·54	,,
Gangue	2·12	,,
Magnesium carbonate and undetermined	·24	,,
	100·00	

Ten miles S.W. from Cobar, and 3 N.W. of Queen Bee Mine, parish Meltie, county Robinson.—Inspector J. Polkinghorne reported (P.B. $\frac{12}{0}\frac{8}{7}\frac{21}{}$):—Slate with quartz veins carrying strong stains of copper carbonates; country strongly impregnated with iron oxide. Aided to sink a shaft 350 feet, and drive 200 feet north and south from bottom.

At 310 feet heavy water prevented continuation of shaft with prospecting appliances; cross-cutting begun; the first 36 feet of the cross-cut was through a lode of very low grade, a little copper showing in places, and small veins of pyrites.

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Cobar Gold-mines (formerly Fort Bourke).—Carbonate of copper has been stacked from oxidised zone. Sulphides are being raised from north level at 437 feet.

Experiments were tried with the Elmore Vacuum Concentrator (three units of a capacity of 150 tons per day being installed by the Elmore Proprietary) towards the close of 1907. So far results have not been disclosed, but are believed to have been unsatisfactory.

If these lean sulphides can be successfully concentrated, they will be useful for fluxing the silicious carbonates; but the tailings and slimes will require separate treatment for their gold contents, unless the workable or recoverable proportion be included in the sulphide concentrates.

Nymagee Division.

Cobar-Lyell Mine, about 3 miles north of Shuttleton, and ½ of a mile from Pine Tank, Priory Run, parish Hume, county Mouramba.—Strike N. 15° W. in slate and sandstone. Inspector H. Hooke reported (P.B. $\frac{A}{0}\frac{5}{5}\frac{4}{4}$):—A copper-bearing formation opened to 15 feet. Aided to sink to 65 feet, and to cross-cut 25 feet at bottom. Progress.—At 40 feet, two bunches of copper ore in gossan cut through; at 65 feet, slate intermixed with small veins of carbonates; aided to continue sinking to 115 feet; at 94 feet, same prospects as at 65 feet; no improvement at 100 feet; cross-cut revealed thin veins of ore for 12 feet; nothing beyond.

Examined by the Writer in November, 1907. Work abandoned. Grey sulphide a few inches thick at 80 feet; apparently occurring in bunches. Some tons of dressed ore at surface, consisting of native copper, carbonates, and grey ore, gave the following returns from an average sample:—

No. 07-7433—Copper, 9·98 per cent.
Gold, 1 dwt. 2 grs. } per ton.
Silver, 2 oz. 9 dwt. }

Crowl Creek-Shuttleton Mine, M.Ls. 3, 6, 7, 8, 9, 12, 14, parish Hume, county Mouramba, 17 miles S.W. of Nymagee, 50 miles from Cobar, and 57 miles from Hermidale Railway Station.—Chief Inspector J. B. Jaquet was the first to officially examine the discovery at Crowl Creek. From his report the following extracts are made, illustrative of the surface conditions, now obliterated:—

"Attention was first directed to these deposits by an aboriginal—Jacky Owen—in November, 1900. Remarkable that they remained undiscovered so long, because of occurrence of green stains of copper carbonate on face of slate cliffs in vicinity. Country slate and schist, identical with Cobar formation. Copper ores do not occur in a lode with well-defined walls and a distinctive gangue, but scattered in bunches and pockets throughout the country. Some of the ore consists of slate with a slight impregnation of copper carbonates, and this ore can be seen passing by insensible gradation into one composed almost entirely of copper carbonate, grey ore, and red oxide, with a gangue of quartz and oxide of iron."

"The most promising deposit hitherto discovered is situated upon Osmetti and party's claim. Here a bunch of slate impregnated with copper carbonate has been exposed for a distance of 75 feet. An open cut has been

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carried down upon this to 18 feet. At bottom a body of excellent ore, at least 7 feet wide, was exposed. Sixteen tons of ore raised and sent to Cockle Creek. On prospector's claim shaft down 40 feet in decomposed schist, more or less impregnated with copper carbonate.

"In Kerwin and party's claim a little carbonate at surface; at 30 feet a bunch of rich carbonate and cuprite."

The northern, or Crowl Creek, section was originally styled the "Commonwealth." After being taken over by the Crowl Creek Syndicate in March, 1902, it was renamed; the Crowl Creek Copper-mining Company being formed at the end of the year.

Amalgamation was effected with the southern, or Shuttleton, section in December, 1906, under the present name of *Crowl Creek–Shuttleton.*

Progress of development is briefly recorded in the following extracts from official reports:—

Inspector Schloesser, in 1902, reported development continuing satisfactorily. Carbonates, oxides, and glance, followed down in the Crowl Creek section to 200 feet; rich portions stoped and sent away. Chalcopyrite proved at 220 feet, 18 feet wide, grade over 17 per cent. down to 250 feet. (Ann. Rept., 1902, p. 79.)

Smelting began in 1903 with four reverberatory furnaces. 1,300 feet of driving and cross-cutting, and 250 feet of shaft and winze sinking executed. (*Ibid.*, 1903, pp. 45, 46.)

Refinery erected in 1904. Air compressor plant, rock drills, &c., installed. Sinking main shaft to 450 feet, with levels at 350 and 430 feet. Good sulphide ore at each level. Value of copper obtained during year, £34,800. (*Ibid.*, 1904, p. 45.)

Main shaft deepened to 630 feet in 1905. Ten thousand tons of ore treated for 950 tons of copper. (*Ibid.*, 1905, p. 80.)

Concentrating plant in course of erection. Main shaft 680 feet. Amalgamated with Shuttleton Mine in December. (*Ibid.*, 1906, p. 45.)

The following extracts from the Seventh Half-yearly Report, 26th September, 1906, afford an insight into scope and cost of production, when in full running order:—

5,150 tons of lodestuff raised during half-year produced 2,652 tons of dressed ore.

4,400 tons smelted for 268 tons rough copper, 233 tons of which yielded 215 tons refined copper=99·75 grade.

Costs.	£	s.	d.	
Mining crude ore	1	6	6·3	per ton.
„ dressed ore (proportional)	2	9	1	„
Dressing crude ore	2	2	9·3	„
„ clean ore (proportional)	0	5	1·2	„
Clamping (heap roasting)	0	3	1·5	„
Smelting per ton of ore to rough copper	1	17	9·4	„

Costs per ton of Copper produced.			
Mining	22	18	3
Dressing	2	18	8
Clamping (heap roasting)	1	3	8·1
Smelting	31	8	10·8
Average cost per ton of rough copper	£57	19	5·9

Total cost of mining and smelting per ton of ore, £3 9s. 8d.

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SECTIONS

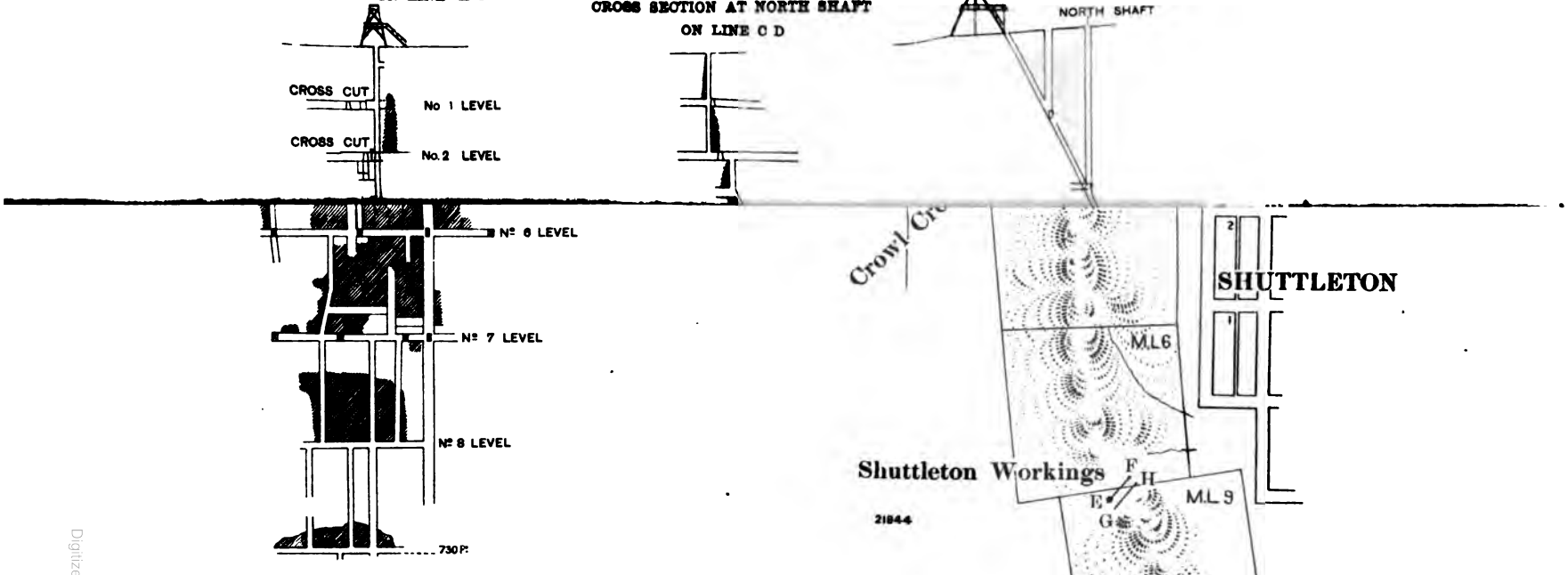
Crowl Creek Working

CROSS SECTION AT SOUTH SHAFT ON LINE A B

Sections Scale 0 40 80 120 Feet

CROSS SECTION AT NORTH SHAFT ON LINE C D

CROSS SECTION ON LINE E F



Taken from Mine Manager's Plan.

PHOTO-LITHOGRAPHED BY W. A. GULLICK, GOVERNMENT PRINTER, SYDNEY, N.S.W.

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The costs at this period were greatly increased owing to difficulty in raising sufficient ore to keep reduction plant running. The evil of the hand-to-mouth policy of establishing a fairly large smelting plant prior to adequate exploration and opening of levels ahead of stoping requirements.

This property was examined by the Writer in October, 1907, immediately after compulsory closing down, owing to financial troubles.

The lodes occur in sandstone and slate close to junction of quartz-felsite, towards which they strike at an acute angle. The main (Crowl Creek) shaft enters the quartz-felsite at 683 feet. The latter occurs on the west side and strikes approximately north and south. The lodes strike north-west, and dip at 58° to 63° south-east.

Three parallel lodes occur in the Crowl Creek section, viz., the "Main," and "East" and "West" lodes. The Main, or Crowl Creek lode, forms a lens which has been worked for a length of 160 feet, and an average width of about 6 feet. A greater width of mineralised rock occurs, but not payable. The ore-lens has been stoped from 630 feet to surface.

Notes on appearance of lodes at time of closing in October, 1907:—

Crowl Creek Section:—

110-*feet level.*—Formation showing good ore in crosscut east.

270-*feet level.*—West, Main, and East lodes opened. Main lode troubled at north end. South end in blank channel rock and quartz—should be driven on.

330-*feet level.*—Mineralised country exposed in crosscut west of West lode. West, Main, and East lodes opened. In West lode at 330-feet level stoped up and followed in winze. Channel rock well defined in face north end. South end not driven on, thin and pinched, but solid pyrites showing; should be driven on.

South end of Main lode at 330-feet level followed for some distance on good ore, ended in strings of quartz with pyrites; should be followed.

North end at 330-feet level, slate with pyrites leanly distributed; traces of copper ore on hanging wall.

530-*feet level.*—Not very productive. Cross-cut west to probably "intermediate" lode, then on to supposed West lode. Small chamber stoped in latter for pyritic flux; fairly solid, reported to contain 1¼ per cent. of copper.

630-*feet level.*—Main lode lens 100 feet long, greatest width 12 feet—of 3 per cent. average. Monkey shaft sunk to 730 feet; greatest depth reached.

730-*feet level.*—Good grade ore at bottom, 90 feet long; greatest width about 18 feet, narrowing to 6 feet. Best grade extends 39 feet north and 16 feet south of Monkey shaft. Hard breaking ground, quartzite. Sump 15 feet deep, half in ore, half in slate on hanging wall. Assay from sump, 7 per cent. copper. Winze 25 feet north of Monkey shaft, depth 7 feet. Assay, 11 per cent. copper from both ends.

On south-west ore dies away in hard quartzite without wall.

The lower developments are decidedly encouraging, there being an improvement at 630-feet level, and still better at 730-feet—where 7 per cent. ore is going underfoot. Following the latter north-west, ore continued for about 90 feet, when a blank was encountered, and further on ore for 60 feet, and still in face.

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Shuttleton section.—No quantity of payable ore cut in this section above 387 feet. At 150 feet strings of black ore occur in crushed slate, not worked. Thirty-four feet west on this level, junction of quartz-felsite met; no ore, but very pyritous slate at contact. North end of 150 feet level driven only a few feet beyond strings of black ore mentioned.

Crosscut south from 150 feet level for 13 feet, strings of rich yellow sulphide in slate, said to average 3 per cent.

First stope opened at 380 feet on underlay; south of shaft at this level, a good lens of ore made in quartzite, but did not extend up beyond about 15 feet. Closed in south, a little ore showing in continuation of south drive in quartzite, under 1 per cent. grade.

At the 445 feet, or lowest level reached—just above water-level—a lens of ore, stoped about 44 feet by 23 feet, continues south, but of poor quality.

The average yield of the Shuttleton ore, as mined, was about 3 per cent.

Mine Water.—Water-level, 330 feet in Crowl Creek section; just showing at 445 feet in Shuttleton.

From bottom of main Crowl Creek shaft (730 feet) 33,000 gallons per day lifted in dry season (October, 1907). Bulk of water (30,000 gallons) from 450-feet level.

Heavy water struck in diamond drill bore east; pressure forced out five lengths of rod.

Underground supply an important item in this dry tract when concentration is necessary.

Concentration Plant.—This plant had just been installed and run for about one month when the mine was closed down. The progress of the ore was from breaker to ore-bin, thence over grizzly to travelling elevator belt of a capacity of about 60 tons in eight hours, set at a moderate angle. On either side of belt vertical shoots at short intervals (connected with ore-bins), into which boys threw direct smelting ore from belt. An average sample of the picked ore from the bins yielded:—

07–7429—Copper, 9·02 per cent.
Gold, a trace per ton.
Silver, 1 oz. 3 dwt. 23 grs. per ton.

The ore left on the belt passes to a second breaker, then to rolls; from rolls to trommel screens. Over-size material gravitates from inclined trommels to an elevator wheel which returns it to rolls.

Fines passing trommel screens, hoisted to upper floor by endless bucket belt fed from trommel launders. Thence to classifiers; overflow passing to two Wilfley tables, the coarser material to two May Brothers' jigs.

Samples of the concentrates from the Wilfley tables and from May Brothers' jigs yielded the following results:—

Assay No.	Description.	Copper.	Gold.	Silver.
		per cent.	per ton.	per ton.
07·7427	Wilfley concentrates	11·58	a trace	1 oz. 6 dwt. 3 grs.
07·7428	May Brothers' jig concentrates ...	8·84	a trace	1 oz. 7 dwt. 5 grs.

The soft, earthy carbonate impregnations of the surface zone were passed through sluice boxes to get rid of excess earthy or rotten slate fines, partially kaolinised.

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COBAR MINING DISTRICT—*continued*.

Smelting Plant.—Consists of four reverberatory reducing furnaces, and one refining, of a capacity of about 100 tons per week each.

Firebrick made from Mount Hope fireclay, which has the following composition :—

No. 07-7432—	Moisture at 100° C.	0·28
	Moisture over 100° C	2·86
	Silica	85·06
	Alumina	8·43
	Ferric oxide	0·70
	Ferrous oxide	0·17
	Manganous oxide	0·04
	Lime	0·32
	Magnesia	0·36
	Soda	0·32
	Potash	0·75
	Titanic dioxide	0·80
	Phosphoric anhydride	0·01
	Vanadic oxide	absent
		100·10

Furnace bottoms formed of crushed quartz which occurs abundantly in barren reefs close at hand.

Ore, sulphides, self-fluxing, clamp roasted.

Output.—The following figures were supplied by Mr. G. Gillimany, late Secretary to the Company :—

	Tons.	Per cent.	
Ore raised and sold prior to March, 1902, when Crowl Creek Syndicate entered into possession	845	26	(average)
Ore raised and sold from March, 1902, to December, 1902	3,024	23·07	,,
From formation of Crowl Creek Company, December, 1902, to closing down, October, 1907 :—			
Ore sold	900	28	,,

Ore smelted, about 40,000 tons for about 2,400 tons of copper, or about 6 per cent.

Mines like Crowl Creek, Nymagee, Mount Hope, &c., are exceptionally handicapped by long team carriage to nearest railway transport, a handicap seriously augmented by frequent droughty conditions imposing almost prohibitive rates on account of fodder scarcity.

Railway communication would unquestionably lead to permanent mining operations on a more extensive scale.

Before the Crowl Creek-Shuttleton lode is reopened, however, it is imperative that adequate prospecting should precede smelting. The furnaces should not be blown in until mining had produced at least six months' supply of smelting ores; development should then be carried on vigorously with continuous augmentation of smelting supply, instead of the previous hand-to-mouth policy of mining under stress of constant smelting demand.

Crowl Creek South Copper Mining Company, N.L., M.L. 17, parish Hume, county Mouramba, formed to prospect adjoining block south of Shuttleton section.

At time of inspection in November, 1907, shaft down 125 feet, a few slight stains of copper carbonate met in a short crosscut about 115 feet from surface. No appearance of lode. Closed.

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COBAR MINING DISTRICT—*continued.*

Donnybrook Lode (New Babinda).—14 miles from Nymagee and 1 mile from Hermidale-road. Parish Nymagee, county Mouramba.

Inspector J. R. Godfrey reported (P.B. $\frac{A\,A\,A\,A}{0\,0\,0}$) stains of copper carbonate in schist and slate. Aided to cross-cut at 80 feet on No. 1 Shaft for 50 feet. Also to sink No. 2 Shaft a further 50 feet, and drive 50 feet.

Inspector Schloesser reported (P.B. $\frac{A\,A\,A\,A}{0\,0\,2}$) strong veins of carbonate at 40 feet in No. 1 Shaft, and heavy gossan with carbonate in No. 2. Aided to cross-cut at 80 feet in No. 1 Shaft. No ore over 4 per cent struck; only small veins.

Aided to sink No. 2 Shaft 50 feet deeper and to drive 50 feet.

Inspector J. Polkinghorne reported (P.B. $\frac{A\,A\,A\,A}{0\,0\,4}$) that the Try Again Syndicate sank the 65 feet shaft a few feet deeper and reported 2 feet of ore averaging 3 per cent. Aided to sink 80 feet shaft 150 feet deeper. At 130 feet, a little sulphides. Aided to cross-cut 25 feet west. At 26 feet in crosscut, traces of copper only—not encouraging; at 157 feet in shaft, indications slight; at 182, specks of copper ore only; at 207 feet, prospects reported better—quartz and black slate with sulphides, and some galena—no further record.

Bourke Division.

Doradilla Copper Lode.—Prospecting area on Doradilla Station, parish Mulholland, county Cooper, about 13 miles east of Mooculta railway siding, and 34 miles from Bourke.

Inspector Polkinghorne reported (P.B. $\frac{A\,A}{0\,0}$) a lode containing copper, gold, and silver. Opened by shaft to 132 feet, driven on southerly at bottom for 37 feet. At 17 feet from shaft a winze down 52 feet. Also short drives at higher levels.

The lode in winze reported as promising. Native copper occurring in lode for full width of winze; east wall not exposed; splashes of grey ore in last 10 feet of winze.

Aided to continue winze to 152 feet.

Cobar Division.

East Cobar Mine.—In freehold of Great Cobar, Limited, in P.G.Ls. 46 and 47—on the strike of the Fort Bourke (Cobar Gold-mines) line of lode, and in a direct line with the Cobar Tharsis Mine.

At time of inspection in 1907 the prospecting shaft was down 100 feet, and a drive was being carried north at that level. A second shaft was being sunk a short distance north in P.G.L. 46. Practically little more than traces of copper had so far been discovered. Shaft 130 feet deep in July, 1908. No fresh developments.

East Cobar Freehold Mine, north of, and adjoining the above mine. No outcrop other than ferruginous slates. On direct line of Fort Bourke—Tharsis lode. The strike being N. 10 to 12° W. Copper first struck in the adjoining East Cobar Mine. Closed down.

No sign of lodestuff above 70-foot level, when carbonates and grey ore appeared on west side of shaft, and gradually widened to about 4 feet at 130 feet. The actual width of the cupriferous belt had not then been proved; cross-cutting being necessary.

A little gold can be panned off from the rubble. The copper ore occurs as an impregnation in slate country.

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COBAR MINING DISTRICT—*continued.*

Water-level, 120 feet, below this could not be kept down with whip. Engine, boiler, and poppet-heads were being installed towards end of 1907.

A sample of best selected ore yielded :—

No. 07-7426—Copper	7·75 per cent.	
Gold	a trace	per ton.
Silver	1 oz. 12 dwt. 11 grs.	

Bobadah Division.

Emerald Prospecting Area.—Inspector Schloesser reported (P.B. 03-2338),—Serpentine carrying a little copper ore and chromite for a width of about 14 feet, near Old Bobadah, and 42 miles S.W. of Nymagee. Aided to sink from 20 feet to 70 feet and to cross-cut 50 feet. Apparently not availed of.

Gilgunnia Division.

Gilgunnia.—Copper ore occurs in small quantity about 2 miles N.E. from Gilgunnia, near The Peak, and on the Gilgunnia-Nymagee Road, about 7 miles from Old Gilgunnia.

Northumble Pastoral Holding.—Six miles south of Sandy Creek Government Tank, parish Carlisle, county Mouramba.

Inspector Polkinghorne reported (P.B. $\frac{21}{07}$) a promising formation with quartz and ironstone leaders in slate, proved 9 feet wide, at the 48 foot level, and carrying traces of copper throughout. Aided to sink from 48 to 148 feet.

Nyngan Division.

Girilambone Copper Mine, Great Western Railway-line, 405 miles west of Sydney, parish Gidalambone, county Canbelego, (situated in portions 2 and 3, originally taken up under volunteer land orders).—The actual date of discovery of this mine is in dispute ; but there is no doubt that it was first opened in the beginning of 1880 by Messrs. Hartman, Campbell, and others, the two named being also connected with the discovery and opening of the Great Cobar Mine.

Mr. Hartman's statement, briefly, was that in 1875, whilst proceeding from the Bogan River to Cobar, he camped at some "gilgai" water-holes, close to Girilambone Hill, and, from his experience at Cobar, recognised the characteristic blue and green stainings of copper carbonates at the site of the present South Shaft. As the outcrop was small he did not set much value on it at the time, but contented himself with taking with him to Cobar a sample of the surface ore.

In 1879, accompanied by his brother-in-law, Charles Campbell, and two others, he again visited Girilambone and marked out four 40-acre mineral conditional purchases, and proceeded shortly afterwards to mine the surface ore, which consisted largely of rich red oxide. His title was then disputed by Messrs. W. W. and T. L. Richardson, on whose run (No. 5 West Bogan) the mine was situated, the latter claiming a prior right by volunteer land orders. According to Mr. Hartman, his partners not being sufficiently impressed with the importance of the deposit—as the red oxide was only from 3 to 12 inches thick in flat layers down to 10 feet—relinquished their claim to it rather than enter into litigation. Mr. T. L. Richardson states that his attention was first drawn the outcrop in 1880 by a stockman on the run, who had been attracted by the colour of the rocks. The land was then secured as already stated. It seems unquestionable, nothwithstanding the conflicting

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dates, that the site was known to the owners of the run prior to the advent of Hartman and party to begin mining, but the action of the latter practically led to the opening of the mine.

Girilambone, in the aboriginal language, signifies "falling star" or meteorite.

The first official record of Girilambone Mine is that by Mr. L. H. G. Young, Geological Surveyor, who visited it in company with the Writer, in 1880. "The copper deposit is situated on No. 5 West Bogan Block, near the north-west corner, and on the summit of a small hill long known as Copper Hill."[1] The lode has a strike N. 18° W., and dips to the eastward at an angle of 56°. A small trench has been made across the lode, showing it, for a width of 18 feet, to be composed of veins of quartz, including between them bands of slate and occasional bunches of extremely rich red oxide of copper coated with green carbonate. The lode may be again seen 100 yards to the north of the trench, and copper indications also occur about 30 yards to the N.E. of the same place. The strike of the slates is N. 12° E." (Ann. Rept., 1880, p. 262.)

In 1881, a company was formed and the mine opened, the lode so far as tested appearing from 6 to 25 feet wide. 650 tons of ore were raised during sinking and driving. Furnaces were in course of erection.

In 1882 the deepest level was 198 feet from the surface; the lode at this point being 6 feet wide. 2,000 tons of ore were raised during the year, but only 10 tons of copper were produced. Mr. T. L. Richardson states that after the furnaces were erected the ore was found difficult to treat, and little was done in this line, the output being sent to the English and Australian Smelting Works at Waratah.

In 1883 130 men and boys were employed until the end of April, when twenty-two only were retained sinking a new shaft. The main shaft reached a depth of 252 feet, the lode varying from 2 to 19 feet in width. 450 tons of ore raised during the year yielded 32 tons 4 cwt. 1 qr. of fine copper, valued at £1,655. Value of plant, £7,500. Population, about 500.

In 1884 prospecting by means of a new shaft was carried on. Chief Inspector W. H. J. Slee, reported in 1886 that bunches of ore were struck at the following levels—86, 122, and 300 feet.

From 1885 to 1893 the mine was not worked.

In 1893 it was let on tribute, and ore extracted to the value of £957.

In 1894 two or more tributes were let, the output being 36½ tons of copper, valued at £1,180.

During 1895–6 the mine was again idle.

In October, 1896, the Girilambone Copper Mining Company, Limited, was formed, and active operations begun, 200 men being employed. The main shaft was deepened to 320 feet. 17,154 tons of ore were raised during 1897; estimated copper contents, 733 tons. Smelting and refining were commenced and 173 tons of copper produced.

The Writer examined developments in 1898.

The country consists of slates and sandstone, with occasional hard bands of quartzite, the latter forming a few low hills in the neighbourhood which are conspicuous features above the general level. Girilambone Hill is of low elevation, with a bare outcrop of rocks, chiefly quartzitic. The copper ores occur as segregations and replacements in the country without the defined limits of ordinary fissure lodes. The matrix consists of silky, schistose, and fine sandy slates, with numerous quartz veins and inclusions

[1] Mr. T. L. Richardson states that this is an error, the name not being known prior to the date mentioned.—J.E.C.

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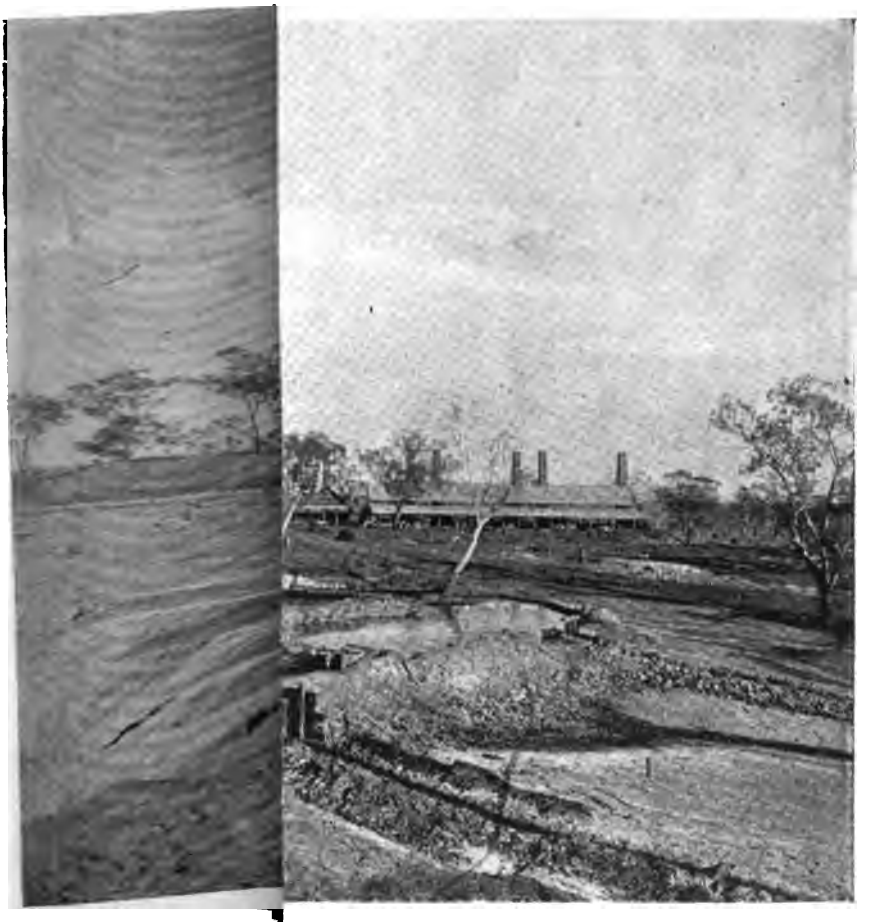

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In an open cut—a relic of early operations—at Datson's shaft, the folding and contortion of the country is well defined by infiltration of copper salts —blue and green carbonates—along the lines of folding, imparting to the mass a wavy banded character.

The zone of surface oxidation extends just below the 200 feet level. The oxidised supplies were being drawn from the 140 feet level in the south shaft. In this lode, isolated patches and nodules of red oxide of copper occur in the softer country, following the wavy folds of a hard quartzite band, locally known as the "ironstone lode."

The carbonate ores are seldom homogeneous and solid, but principally earthy and pulverulent; even the apparently pure azurite particles contain little more than half the theoretic value in copper, whilst the malachite rarely approaches even this proportion.

Between the zone of complete oxidation and the unaltered sulphides at 220 feet, there is a gradual transition, the upper extensions of the sulphides being coated, and in places entirely converted partially into loose earthy melaconite—black oxide of copper—and partially into sub-sulphide, which, unfortunately, are difficult to save in concentration.

Serious difficulties at Girilambone are the close association of silica (quartz) with the copper ores, and the absence of solid iron sulphides. Wherever the copper ores occur most concentrated in either the oxidised or sulphide zones, quartz is most abundant; hence, owing to the nature of the ores, and the mode of their occurrence in the matrix, concentration by jigging results in a high percentage of silica being retained with the ore. The clayey material of the earthy ores, and the soft schistose matrix, is mostly removed during the operation. The first concentrates, which are used for fluxing the oxidised ores, contain about 53 per cent. of silica.

Development to 1908.—The main shaft reached 544 feet, but for the last 120 or 130 feet it had passed out of the lode, which had dipped away from the shaft. The deepest working level was 300 feet, but another was being driven at 520 feet. Other working levels were the 200 and 140 feet. The south lode was connected with the main shaft by a cross-cut at 140 feet level, through which all the haulage was done. The south lode strikes about north-west whilst the main lode has an apparent east and west course.

In the fifth half-yearly report—28th February, 1899—Mr. W. Blakemore, mine manager, stated that the main shaft, 544 feet deep, had been securely timbered and divided into compartments. Little work was done at the 360 feet level—insufficient to determine the value of the lode at this depth. At the 300 feet level, the west drive had been extended 70 feet on the course of the lode. Ore stoped, 25 feet wide, 200 feet level. A new stope opened in south-west drive, consisting of malleable copper, grey and carbonate ores. No work performed at the 140 feet level during the half-year beyond completing the cross-cut to the south workings.

A new tank of 6,000 cubic yards excavated; old tank cleaned out.

Treatment of the Ores in 1898.—The oxidised ores from the upper levels were roughly sorted at the surface by hand picking and screening, the richer portions going direct to the smelter's charging bins; poor lumps were discarded, and the balance sent to the ore-breaker for preparation for the jigs. The sulphides on the other hand went direct to the jigs.

The ores raised were divided into three classes, distinguished as "carbonates," which included the red oxide and carbonates from the south lode, "sulphides," which embraced all the sulphides from the 240 and 300 feet levels, and "oxides," from the transitional zone between the former.

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The "carbonates," as mined, had an average assay value of 4·6 per cent., according to the half-yearly statement for June 30th, 1898, which is based on weekly average assays. About 40 per cent. of this class of ore was sent direct to the smelters after breaking and picking, and averaged 13 per cent. A small proportion was discarded, and the balance went to the ore-breaker and jigs. The screenings of this class naturally formed a considerable part of the whole, owing to its soft earthy nature. The richer portion, which went direct to the charging bins, consisted chiefly of isolated lumps of red oxide, coated with carbonate and associated with quartz.

The "sulphides" and "oxides" went direct to the concentrating plant, which consists of a Gates rock-breaker, Cornish and Krom rolls, and Handcock's and May Brothers' jigs. Wire-wove ¼-inch mesh trommel screens are used in connection with the rolls.

Each class of ore was treated separately. The crushed material from the breaker was divided between the Cornish and Krom rolls, the coarser material from the former passing to a Handcock's jig[1] (of obsolete pattern), and the finer from the Krom to May Brothers' jig.

The first concentrates went to the charging bins, the seconds were stacked for further possible treatment, the balance passing to the waste heap.

From the detailed statement for the half-year under existing conditions it has only been possible to obtain from the picked ore and the workable concentrates about 66 per cent. of the estimated contents of the output. This percentage is still further reduced by loss in smelting. The actual extraction approximates to about 50 per cent. of the estimated contents of the ore raised.

(*a*) Concentration.—The earthy carbonates and oxides (chiefly screenings), were concentrated to an estimated average assay value of 10·9 per cent. of copper, but a glance at the "seconds" revealed a considerable loss, chiefly in blue carbonate. Attention was given by the Writer to the possibility of mechanically separating these particles after careful sizing, but the difference in specific gravity between the carbonate and the waste was so slight (0·73) as to render mechanical separation impossible. The green carbonate particles, which are also conspicuous on the "second concentrates" heap, need only a glance to establish the fact that their copper contents are more apparent than real. Mostly, the green particles are quartz stained by malachite, the average specific gravity of which is 2·74, whilst that of the slate waste is 2·72. An assay of apparently pure azurite (blue carbonate) yielded only 31 per cent. of copper as against 53·2 per cent. in the pure mineral. In view of these facts, it did not appear that the loss could be averted in mechanical concentration.

The most important question in concentration, however, refers solely to the sulphides, the estimated copper contents of which were increased from 3·1 to 6·5 per cent., and the estimated extraction to about 50 per cent.

It has been demonstrated that there is little hope of better mechanical recovery in the case of the carbonates and oxides; the question, therefore, is whether cleaner concentration is possible in the case of the sulphides. In the first place, the copper and iron sulphides mainly occur sparingly distributed through a greenish schistose slate, and it is specially noticeable that where the sulphides occur most concentrated, that quartz is abundant.

To crush direct to a fineness sufficient to free all the scattered sulphide crystals would, probably, in the absence of an abundant water supply, increase instead of reduce the present loss, owing to the great tendency of the matrix to slime. From a study of the nature of the ore, and the natural

[1]Since replaced by one of Handcock's latest and most complete jigs, having a capacity of 100 tons per day.

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Girilambone Copper Mine.

(Main Drive, No. 1 level.)

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difficulties of concentration, a few possible improvements in manipulation suggest themselves; the most important being preliminary sorting of the ore on the surface in place of crushing everything as it comes from the working faces. It is unquestionable that a good deal of absolute waste was going to the jigs at the time of inspection, and adversely affecting the results proportionately with the quantity added. If the sulphide ore was screened, and the larger material broken and sorted by cheap boy or elderly labour, a good proportion of waste could be at once discarded, and possibly a percentage of smelting ore selected, the balance and the screenings going thence to the concentrating machinery.

In view of the tendency to slime, the first crushing should not pass a finer mesh than at present. If, however, the seconds offer sufficient inducement, a further and finer crushing might follow with further jigging, though far better results would be obtained by use of buddles or vanners. Both the latter are in extensive use in Montana, United States, where fine crushing and concentration are carried out on a large scale. The Anaconda Company are understood to have adopted buddles wholly for the fines.

According to Dr. Peters, junior,[1] even with the most approved apparatus, and careful running, it is usually impracticable to concentrate sulphide ores of copper with a loss of much less than 25 per cent. With copper glance and bornite, Dr. Peters' experience has been a loss of 33 per cent. in concentration.

In large low-grade silicious deposits, it therefore becomes a question for consideration, after careful testing, whether it would not be more advantageous to waste a proportion of the ore in the "seconds" than attempt to save it at an increased cost for further operations.

The following copy of one of the half-yearly returns of the Company's operations will reveal the nature and proportions of the different grades of ore raised, and the results of dressing and concentrating operations:—

THE GIRILAMBONE COPPER-MINING COMPANY (NO-LIABILITY). Half-year ending 30th June, 1898.

Ore raised and jigged—	tons.		per cent.		tons cwt.		*Copper contents.* tons cwt.
Carbonates	2,579	@	4·6	=	118 12	}	
Sulphides.....	3,263	@	3·1	=	101 3	}	283 12
Oxides	953	@	6·7	=	63 17	}	
	6,795						
Screened Ore—							
Carbonates	1,109	@	13·0	=	144 3	}	
Sulphides.....	44	@	2·8	=	1 4	}	145 7
	7,948						428 19
Jigged Ore—		*Producing.*					
Carbonates, No. 1 ...	464	@	10·9	=	50 11	}	
Sulphides, No. 1.....	706	@	6·5	=	45 17	}	139 10
Oxides, No. 1.....	273	@	15·8	=	43 2	}	
,, No. 2	859	@	3·5	=	30 0	}	
,, No. 3	64	@	4·0	=	2 11	}	101 8
Tailings	2,994	@	2·3	=	68 17	}	
Slimes and waste ...	1,435		....			(say)	42 14
							283 12
Screened Ore—							
Carbonates	1,109	@	13·0	=	144 3	}	
Sulphides.....	44	@	1·4	=	1 4	}	145 7
							428 19

[1] Modern Copper Smelting, 7th edition, 1895, p. 611.

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COBAR MINING DISTRICT—*continued*.

The concentrating plant was reorganised by Mr. L. G. Handcock, in 1901, Wilfley tables being installed in addition to the jigs in use; and again remodelled in 1906.

Results achieved.

Half-year ending 30th June, 1901.

2,178 tons of ore milled, producing 360 tons concentrates.

Half-year ending 31st December, 1901.

2,964 tons crude carbonates, averaging 3·6 per cent., producing 405 tons concentrates = 12·8 per cent.; 447 tons crude sulphides, averaging 3·2 per cent., producing 73 tons concentrates = 9·7 per cent.

Half-year ending 30th June, 1906 (mill restarted).

3,151¾ tons of ore milled, yielding 566¾ tons concentrates = 10 per cent.

Half-year ending 31st December, 1906.

3,190 tons of ore milled, yielding 699 tons 17 cwt. 2 qrs. concentrates = 10·9 per cent.

Half-year ending 30th June, 1907.

5,409 tons of ore milled, yielding 928¼ tons concentrates = (Value not stated).

Half-year ending 31st December, 1907.

3,626 tons of ore milled, yielding 754 tons concentrates = 7·77 per cent.

Smelting.—Smelting operations at Girilambone are greatly hampered by deficiency of sulphur and iron and excess of silica.

Owing to the want of sulphides in more concentrated form to charge with the oxides and carbonates reduction is too rapid, the first regulus occasionally containing over 70 per cent. of copper. In roasting such rich matte, black slags frequently result, containing prills of metallic copper equalling 8 to 12 per cent.

The following figures represent the average assay results of silica and iron obtained by the Company's assayer and analyst—Mr. H. Elphinstone—from the different classes of ore and the flux forming the furnace charges in 1908.

	Silica per cent.	Iron per cent.	
Carbonates and red oxide..... ...	45·2	17·8	Average of 19 weekly assays.
Sulphides	46·2	24·4	,, 24 ,,
Oxides and sulphides	44·4	18·7	,, 10 ,,
Ironstone flux	16·2	49·	Average assay.

The charge consisted usually of 18 to 20 cwt. of carbonates and oxides, 10 cwt. of sulphide concentrates, and 12 cwt. of ironstone flux; but the latter varied according to percentage of silica in the charge. Two barrow-loads of charcoal were added with each fresh charge.

Owing to the want of sulphur, only about two charges per shift were possible—some, indeed, occupied seven hours in reducing. Later it became necessary to obtain sulphide flux from Cobar, but this supply was stopped in 1907. The regulus, or matte, usually from 60 to 70 per cent. grade, was tapped after the fourth charge. In the roasting furnace it was reduced to pimple copper, and then passes to the refinery, which was put in operation monthly.

The output of copper for the eleven months ending 31st August, 1898, during which the furnaces had been running, amounted to 389 tons, equal to a monthly average of 35·3 tons; the last six months averaging 30·6 tons, against 41 tons for the first five months.

Furnaces.—The deficiency in sulphur and iron, and the highly silicious nature of the ores at Girilambone, render reverberatory furnaces most suitable.

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Girilambone Copper Refinery.

(Ladling refined copper into ingot moulds.)

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An abortive attempt with a small blast furnace was made in 1899. The smelting plant consists of five reducing and one refining furnace. The dimensions of the former are 21 feet x 15 feet and 20 feet x 15 feet. The previous furnaces were built of Waratah firebrick, of which the crowns of those now in use are constructed. Locally manufactured bricks, however, are now entirely replacing the former, and are found to answer well, having a life of about eight weeks in the bridges and throats of the furnaces.

In the section devoted to refractory materials and fireclays, analyses of both Waratah and Girilambone fireclay will be found. The Girilambone is essentially a silica brick—being composed of about 95 per cent of pure quartz gravel and sand, the balance being an aluminous clay resulting from the degradation of the soft schistose slates of the vicinity. The material is obtained about 1 mile from the mine. When burnt, the bricks resemble ordinary "red brick" in appearance.

Furnace mortar is prepared from the finer clay, ground firebrick, and slimes. Furnace bottoms are prepared from quartz from the numerous reefs of the locality. Ironstone flux is procured about 6 miles from the mine. Limestone, occasionally used in freeing the furnaces, is brought by rail from some distance.

Wood is used for firing, the supply being conveyed by horse teams.

Water Supply.—Water supply is a serious consideration at Girilambone, owing to the necessity for concentration. Fortunately the mine workings furnish from 40,000 to 45,000 gallons per week. There are no natural channels worthy of the name in the vicinity, so that conservation is by open tanks. The mine water is used for concentration. From the jigs it passes to temporary filter dams, from which it is pumped back and constantly circulated.

The smelting operations are clearly defined in the following copy of the Half-yearly Report, ending 30th June, 1898:—

	Ore smelted.				*Copper Produced.*	
Concentrates—	Tons.		Per cent.		Tons cwt.	Tons cwt., qrs. lb.
No. 1 Carbonates.....	464	@	10·9	=	50 11	
No. 1 Sulphides.....	706	@	6·5	=	45 17	
No. 1 Oxides	273	@	15·8	=	43 2	
Old Stock—						
No. 1 Carbonates.....	107	@	10·1	=	10 14	
						150 4 0 0
	Screened ore.					
Carbonates	1,109	@	13·0	=	144 3	
Sulphides.....	44	@	2·8	=	1 4	
						145 7 0 0
						295 11 0 0

Summary.—The size and permanence of the Girilambone lodes are well assured; the grade, however, is low when the nature of the matrix and the mode of occurrence are considered. In actual yield it compares very favourably with mines affording profitable returns, but the absence of solid sulphides prevents smelting concentration by blast or pyritic methods. Future success appears to depend upon a larger water supply and more efficient mechanical concentration. The concentrating plant should be allowed a campaign ahead of smelting operations to ensure an adequate and continuous supply for the furnaces.

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COBAR MINING DISTRICT—*continued.*

Output for the half-year ending 31st December, 1898:—Ore raised, 6,487 tons, averaging 3·85 per cent., equal to 249 tons 14 cwt. 3 qrs. 26 lb. of fine copper; consisting of—

	tons.
Sulphides	4,252
Carbonates	2,153
Oxides	82
	6,487
Ore jigged—Sulphides	4,252
Carbonates	871
Yielding respectively—Sulphide concentrates	958
Carbonates	442
	1,400 tons, of an average value of 8·76 per cent.,

together with 1,281 tons of unjigged 10 per cent. carbonates, making a total of 2,681tons sent to the furnaces for smelting. 2,371 tons smelted yielded 215 tons of fine copper.

The subsequent history corresponds with the earlier in its chequered character. Development has not been continuous, long periods of entire or partial idleness alternating with active work. For a number of years mining operations practically ceased, experimental tests were proceeding for recovery of the large amount of copper locked up in accummulated tailing heaps, with final adoption of a leaching process.

From the records of the Company, the total tonnage of ore extracted from the date of opening in 1881 to the end of 1907, amounted to 58,408 tons, and the total copper produced—1,141 tons 13 cwt. 1 qr. 19 lb.

The process of recovery since the adoption of the leaching process is illustrated in the following extracts from the Company's Half-yearly Reports:—

Leaching of tailings.—The oxidised tailings were treated with sulphuric acid in a vat, the resulting solution with sulphuretted hydrogen gas, and the copper precipitated with scrap-iron. This process was started in April, 1903, but serious leakage of cylinders caused a stoppage. The results achieved to 4th July, 1903, were as follows:—

Half-year ending 30th June, 1903.

Weight of tailings. Tons.	Copper contents. Per cent.	Total copper contents. Tons.	cwt.	qrs.	lb.
1,481	2·5	30	5	1	0
Copper precipitate obtained		19	12	2	0
Residues, 1,451 tons; copper contents, 0·65 %		9	8	2	0
Waste solution (say)		1	4	1	0
		30	5	1	0

Extraction of copper in form of precipitate equal to 64·8 per cent.

Half-year ending 31st December, 1903.

Weight of tailings. Tons.	Copper contents. Per cent.	Total copper contents. Tons.	cwt.	qrs.	lb.
2,628	1·96	51	9	3	0
Copper precipitate obtained		34	5	2	0
Residues, 2,575 tons; copper contents, 0·58 %		14	8	2	0
Waste solution (say)		2	5	3	0
		51	9	3	0

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COBAR MINING DISTRICT—*continued.*

Further experiments in leaching resulted in installation of larger plant. Operations began in September with the following results to end of 31st December:—

Half-year ending 30th June, 1904, and 31st December, 1904.

Weight of tailings. Tons.	Copper contents. Per cent.	Total copper contents. Tons.	cwt.	qr.	lb.
2,477	2·46	60	19	1	8
Copper precipitate obtained		35	3	2	15

For the ensuing half-year the following results were recorded:—

Half-year ending 30th June, 1905.

From 7,241 tons of tailings, containing 2·14 per cent. of copper, the extraction was not more than 1·24 per cent., leaving 0·90 in the tailings. The presence of sulphides in the tailings caused this low extraction.

Half-year ending 31st December, 1905.

4,288 tons of tailings, containing 2·13 per cent. of copper, yielded 50 tons 8 cwt. of fine copper.

Half-year ending 30th June, 1906.

854 tons of tailings treated; particulars not given.

Half-year ending 31st December, 1906.

574½ tons of tailings treated for 8 tons 16 cwt. 2 qrs. 5 lb. fine copper.

Half-year ending 30th June, 1997.

1,344 tons of tailings treated for 17 tons 8 cwt. 3 qrs. 20 lb. refined copper.

Half-year ending 31st December, 1907.

1,222½ tons of tailings treated for a recovery of 14 tons 12 cwt. 1 qr. 14 lb. refined copper.

In 1899, 1,288 tons of ore and slag, averaging 3·91 per cent. of copper, were smelted in a small experimental blast furnace, for a return of 50 tons 8 cwt. of copper.

A new furnace (reported to be of the Orford type) of 500 tons capacity was also erected at considerable expense, but proved altogether unsuitable, after an intermittent trial from October to end of December.

Girilambone Company reconstructed February, 1902.

Magnetic separation tried in 1901.

From a quantity of ore sold to public smelters in certain years, it appears that the carbonate concentrates ran to about 12·5 per cent., the sulphides to 9·5 per cent., and Frue vanner fines to 12·8 per cent.

Pulveriser installed in 1904 for reducing coarser tailings.

Mine unwatered in 1905; a little ore won for furnaces. Work proceeding in Nos. 1, 2, and 3 levels in 1906 and 1907. Cobar sulphide supply stopped in 1907.

During the half-year ending December 31st, 1907, all work suspended, with exception of keeping mine unwatered and plant in repair, owing to fall in price of copper.

Girilambone District.—About three-quarters of a mile northerly from Girilambone Mine, Christensen and party took up a mineral conditional purchase of 40 acres, embracing a gossan outcrop, and sank 90 feet in it. A little carbonate of copper was obtained from the bottom of the shaft.

About 3 miles north-westerly, Hartman and party opened another gossan outcrop, under aid from the Prospecting Vote, to a depth of 150 feet, and drove upon it for 200 feet. In the drive, carbonate of copper veins were cut, but were not payable.

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COBAR MINING DISTRICT—*continued.*

Day Bros.' Mine.—Portion 11, parish Wilgabone, county Canbelego (A. Leslie's settlement lease). Chlorite schist, with traces of copper ores. Aided to sink (P.B. $\frac{2}{0}\frac{2}{5}$) from 25 feet to 150 feet, and cross-cut 100 feet east and west. No payable ore discovered.

Elletson and Party's prospecting claim, on a line with Day Bros. and Great Western Mine, 8 miles from Girilambone. Sample from a 70 feet shaft in chlorite schist, with stains of copper carbonate, yielded—

No. 07-7488—Copper, 0·8 per cent.
Traces of gold and silver.

Cobar Division.

Gladstone Mine.—Wrightville, Cobar. Inspector Polkinghorne reports shaft 186 feet deep. Cross-cut east from bottom 20 feet (on 2nd July, 1908). At 2 feet, 7 feet, and 10 feet from shaft, rich grey sulphide veins cut, having thickness of 4, 2, and 3 inches. Balance of cross-cut in ferruginous slate and quartz.

Mount Hope Division.

Great Central Copper Mine.—Parish Mount Hope, county Blaxland. This mine was first opened about 1878, under the name of "McDowall's," after the discoverer. South Mount Hope, originally known as "Brown's" and afterwards as the Comet Mine, is now also included in the Great Central property.

The first official record is that by Mr. L. H. G. Young, Geological Surveyor, who visited the site in 1880, accompanied by the Writer. (Ann. Rept. 1880, pp. 260–1). Writing of South Mount Hope (Brown's), Mr. Young states:—"Here copper ore has been found in five or six places, but in my opinion the presence of a well-defined lode has not been established. The veins appear to run in a north and south direction, and are composed of quartz, earthy carbonates, red oxide, and a little grey and yellow sulphides; the rock adjoining the vein is a breccia of the porphyry of which the hill is composed."

Of McDowall's (Great Central) Mine, Mr. Young wrote:—"The mineral deposit on this lease consists of a large mass of porphyry breccia, the pieces of porphyry being cemented together by oxide of iron containing a little copper; thus an assay of some of the cementing matter has been made by Mr. W. A. Dixon, F.C.S., and gave 4·32 per cent. of copper. Two shafts have been sunk, one—I was told—to a depth of 70 feet; but as this was half full of water at the time of my visit, I cannot tell what light it has thrown on the value of the property. Amongst the materials excavated I noticed some earthy carbonates and a little rich red oxide of copper. For a distance of 50 yards round the main shaft the rock is literally seamed with veins of red oxide of iron, varying in thickness from a film to 2 inches."

Inspected by the Writer again in 1898.

The Central and Comet workings are situated on the north and south slopes of the Central Hill—a mass of porphyry of some elevation. A distance of nearly half a mile separates the extreme north and south workings. The principal outcrop occurs at the south end, where the Great Central Company's operations were carried on. Here the porphyry, for a width of about 300 feet, is stained with copper carbonates, and seamed with thin veins of ferruginous oxide of copper. Four shafts had been sunk very close together on a band of lode-stuff on the east side of the spur, and numerous shallow trenches and potholes were sunk on chutes of ore between the eastern and western

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workings, but no crosscut has been extended across the intervening formation. The shafts were very rough, and inclined at all angles, making haulage difficult.

The greatest depth attained was only about 240 feet. At this level, sulphides take the place of the oxidised ores. A drive at this depth revealed an improved grade of yellow ore below the hauling shaft. A main shaft, with a proper system of levels and crosscuts, was badly needed. Judging from existing conditions, robbing the rich chutes, without regard to future developments, appeared to have been the method of winning.

The matrix of the oxidised ores is decomposed porphyry, and consequently is soft and earthy, requiring a plentiful water supply for efficient concentration of the leaner grades, which, unfortunately for then existing operations, was not available. One small tank, and a mine-supply equal to about 1,000 gallons per twenty-four hours, constituted the total provision. The surface configurations of the locality are eminently suitable for water conservation. An attempt was being made to turn the mine water to account in concentrating the leaner ores; but a glance at the jigs in operation, with such an inadequate supply, revealed a sludge, from which clean, or even approximately clean, work was an impossibility, in view of the constant re-use of the water. The jigs in use were modifications of the Handcock jig.

Following the strike of the lode northwards, a belt of hard felsitic rock (elvan) crosses the ridge obliquely to the north-west; hereabouts the lode has not been traced by surface prospecting. Over the ridge, however, defined ore channels are encountered, which have been followed some distance south in the Comet workings. The main shaft of the Comet has been sunk, 242 feet, and driven south as stated. Parallel ore veins occur here for a width equalling that of the Central workings. To the north from the shaft the country falls into a low saddle between the Central and a similar hill a short distance north. In this saddle is situated Brown's original discovery, known as South Mount Hope, an eastern lode distinct from that in the Comet.

On the east side of Central Hill, south of Brown's lode, two parallel lodes, one possessing a well-defined outcrop of ferruginous quartz, in which copper ore is visible, and gold, by assay, to the extent of 4 dwt. per ton. It has been opened in one place to a depth of about 50 feet, and the other lode—to the west—to 30 feet. It is reported that ore from these occurrences was sent to the smelters. They are worthy more systematic testing than they have yet received; indeed, the whole cupriferous belt embraced by the Great Central property offers considerable inducement for systematic proving, which should precede any present large outlay for improved plant. The latter could then be laid down on lines commensurate with the developments. The oxidised ores were hand-picked, the firsts going to the smelters, the balance to the breakers and jigs; the sulphides all pass through the latter. The former were concentrated to about 14 per cent., and the latter to 12 per cent. Ironstone flux was obtained from the mine, and fireclay from the New Mount Hope deposit. The smelting plant consisted of three reverberatory furnaces—two reducing and one refining.

In 1900 the mine was taken over by the Option and Development Company, water being conserved and up-to-date machinery installed. Closed down at end of 1902. The shaft not disclosing the ore-bodies expected, the lowest level reached being 500 feet. 400 feet of driving was done at the 300 and 500 feet levels. The treatment plant erected by the

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new company is reported to have cost about £16,000, but no attempt was made to put the plant in operation, owing to the small quantity of ore obtained. A striking instance of putting the "cart before the horse."

RETURNS of the yearly output and progress of the Great Central Copper Mine, compiled from the Annual Reports of the Department of Mines.

Year.	Ore raised.	Copper produced.	Value.	Deepest Shaft.	Deepest level.	Width of lode.	No. of Furnaces.	Value of plant.	Men employed.	Remarks.
	tons.	tons.	£	ft.	ft.			£		
1881	..	..	..	..	..	..	..	..	..	
1882	..	..	..	..	..	..	..	..	..	
1883	1,130	187	8,700	120	120	3 in. to 11 ft.	..	2,000	102	Total ore raised since starting, 1,551 tons.
1884	2,221	336	14,784	206	150	1 ft. to 13 ft.	..	4,000	150	
1885	..	..	..	..	..	..	..	..	..	Work suspended owing to low price of copper.
1886	..									
1887	..	..	..	..	..	..	..	..	..	
1888	..	142	..	..	..	..	..	..	130	Working eleven months.
1889	2,000	394	15,740	..	..	..	..	..	90	
1890	1,855	228	..	242	192	..	..	..	70	1,667 tons smelted.
1891	..	..	..	..	..	..	..	..	..	Mine closed.
1892	..	..	..	..	..	..	..	..	..	"
1893	..	..	..	..	..	..	..	..	..	"
1894	..	..	..	..	..	..	..	..	..	Ore to the vlaue of £4,000 raised.
1895	900	134	5,093	242	192	..	..	..	..	
1896	454	55	2,195	..	..	..	..	..	..	Six months' work only.
1897	1,200	..	..	..	..	..	..	..	50	Mine let on tribute. Ore raised valued at £4,500. Engaged repairing plant, &c.
1898	1,100	110	5,800	..	..	..	..	..	..	

The late Mr. J. Doust, Managing Trustee for the previous owners of the mine, stated that the total output of the mine, according to the mine books in his possession, amounted to 2,170 tons of refined copper, of an assay value of from 99·15 to 99·65 per cent. The refined metal was free from deleterious impurities.

Cobar Division.

Great Cobar Copper Mine Co.—Parish Cobar, county Robinson, 110 miles south of Bourke, on the Darling River, 80 miles west of Nyngan, on the Bogan River, and 459 miles west by rail from Sydney. The Cobar Company's property consists of 1,100 acres of freehold, on a portion of which the town of Cobar is built.

Historical.—Cobar ("Hopah" in the aboriginal) signifies "raddle" (earthy iron oxide), and from the outcrop of the copper lode the aboriginals formerly obtained it for decorative purposes. In process of time a small circular excavation resulted from scooping out the soft ochreous material, forming a catchment for water and serving as a "native well."

The native name "Hopah" sounds like a corruption of "copper," but the genuineness of the meaning given it by an old Bogan River aboriginal in 1898, has recently been strikingly verified by another native of the district—Jack Torrance—for twenty-two years black-tracker in the Police Force.

In 1869, two Danes—Thomas Hartman and Charles Campbell—engaged boring for water in the district, camped at the "native well," and were attracted by the rusty sediment at the bottom, and the blue and green stains on the sides, and for a limited extent around it. Neither were, at that time, acquainted with copper ores. The story of the facts leading to the discovery of the real nature of the colour which arrested their attention is in dispute. Briefly, the account given by Hartman is that, on raking the ashes of the camp fire made alongside the well, he discovered beads of metallic copper, which he took direct to Bourke and there displayed. The

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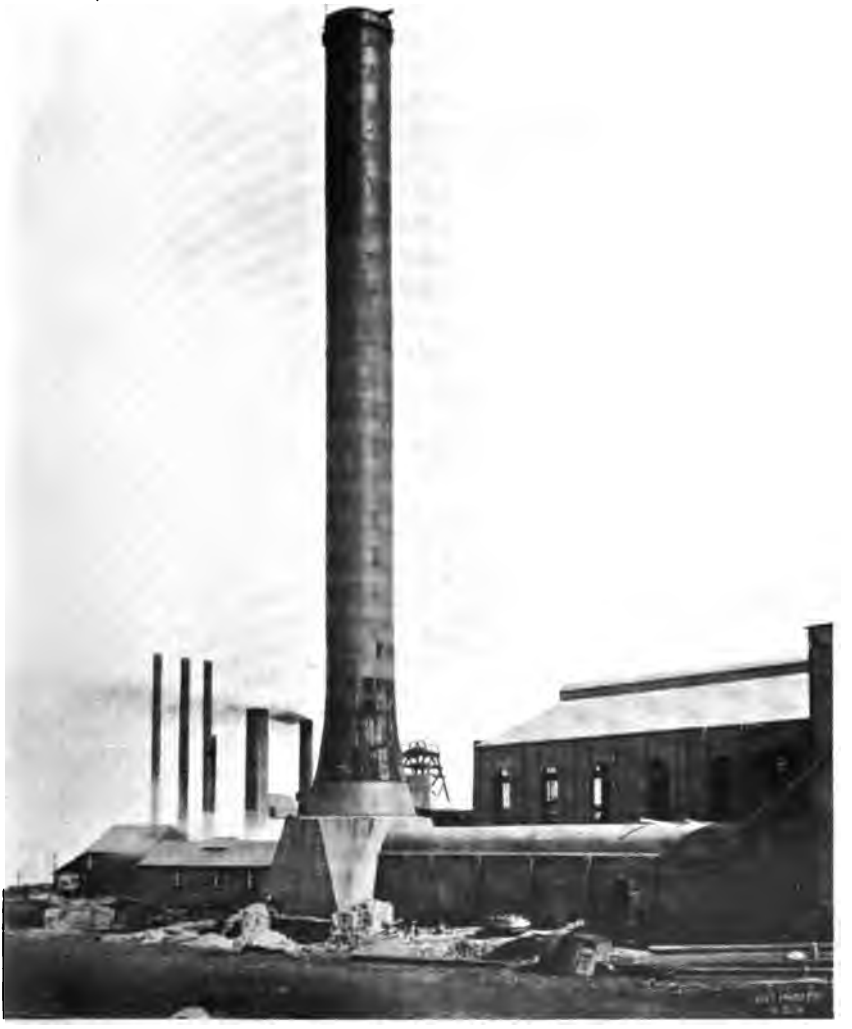

H. Lowell Price. **Great Cobar Copper Mining Company.**

(Main Stack, brick-lined, self-contained. Height 200 feet; inside diameter at top 14 feet.)

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conflicting story is that Hartman and Campbell, taking with them specimens of the coloured rock, proceeded on their journey until they fell in with a Cornish woman—Mrs. Kruge,—the wife of a countryman, who at once recognised the true nature of the colouring. On ascertaining its value, Hartman and Campbell returned to Cobar, and subsequently (on the 6th of October, 1870, according to Mr. Russell Barton), at Fort Bourke, secured the land as a mineral conditional purchase of 40 acres, in conjunction with the late Joseph Becker of that place. The latter, in May and June, 1871, also secured 40-acre blocks adjoining the Cobar on the north and south. In January, 1876, the South Cobar Mining Company was amalgamated with the Cobar under the present title of "Great Cobar."

From inspection of the portion of the outcrop and the native well, remaining intact in 1908, it seems improbable that native copper occurred directly on the surface, in which form alone could it have been melted into the beads reported by Hartman, for there is no question that the small camp fire could not have reduced the metal from its ores. Circumstantial evidence, therefore, supports the rival story; but none the less the credit of discovery rests with Hartman and Campbell, whose intelligent curiosity prompted transport of specimens which had drawn their attention. Lack of this valuable trait has frequently led to sources of wealth being undeveloped for years, until the advent of one of greater inquisitiveness or knowledge. In contrast to the action of the Cobar discoverers, the Writer recalls the statement of a shepherd he met at Mount Hope Copper-mine shortly after its discovery. Located within a few hundred yards of the outcrop on Mount Hope, he had often remarked the blue and green colours as he followed his flock over it, but intelligent prompting was wanting in this case.

Prior to the discovery of payable tin ore in New England in 1872, the gold miners were greatly hampered by the heavy black sand (tin oxide) in their sluices, which caused endless trouble in separating the gold. Instances might be multiplied, but sufficient has been written to illustrate the value of intelligent curiosity in regard to Nature's mineral treasures, many of which—unlike copper—she dresses in very unattractive garb, but which, nevertheless, possess distinctive characteristics, either of form or gravity, which compel attention. Notice might here be drawn to the ready means of identification available to even the poorest which the Government of the State has wisely established—a free laboratory and experts to determine the nature and value of any substance discovered, without cost to inquirers, have been provided in connection with the Department of Mines.

Shortly after operations were started at Cobar by Hartman and Campbell, Mr. Russell Barton—since well known in connection with copper-mining in the State—passing the locality, visited the mine, and, being greatly impressed with its possibilities, from the insight he had gained in South Australian copper-mining, purchased an interest. Rich ores were extracted from near the surface and dispatched by team to the Darling River at Bourke, and thence by river steamer to Port Adelaide Smelting Works, South Australia. Some 3,000 tons are reported to have been thus disposed of at a profit.

In January, 1876, the Cobar and Southern Cobar Copper-mining Companies (Limited) were amalgamated under the title of the Great Cobar Copper-mining Company (Limited) of 80,000 shares of £1 each. (For particulars of the Southern Cobar Mine, *see* description under that title, page 245.)

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Extraordinary difficulties faced the new company. A mine situated 459 miles (railway measurement) from the sea-board, in an arid tract, destitute of natural drainage channels (the nearest being the Bogan River, 80 miles distant), subject to drought, with an unevenly distributed annual rainfall, averaging only 17·21 inches according to the late Government Astronomer, and a greedily absorbent sandy soil.

The nearest railway at the beginning of operations was Blayney (opened in November, 1876), distant by the present railway-line 287 miles from Cobar. In April, 1877, the Orange extension was opened, which reduced the distance to 267 miles. The ordinary roadway, however, probably covers a much greater distance between the points mentioned.

That the Company was enabled under such handicaps to pay dividends, amounting to more than two and a half times the total capital, is eloquent testimony to the richness of the mine. In 1889 operations had to be suspended owing to the extremely low price of copper and excessive cost of transport. The failure of the Société des Metaux and the collapse of the "copper boom" it had originated were the direct causes of the Company's suspension, as an agreement had been entered into for a term of three years with the Société for the purchase of the entire output from the Cobar Mine at £60 per ton on board ship at Sydney. In 1893, however, the mine was let on tribute to the Great Cobar Mining Syndicate, which began operations when the average value of copper was but £39 per ton, and successfully introduced the cheaper and more rapid blast-furnace method of reduction, which revolutionised the copper industry at Cobar. A previous attempt with blast-furnaces (not water-jacketed) was made in 1885, when three were erected at a cost of £5,000. After a short campaign with charcoal fuel they were discarded, though the Mine Manager, Mr. J. Dunstan, regarded some of the experiments as satisfactory. 325 tons of ore were smelted in these furnaces. The cost of charcoal alone would have rendered profitable working impossible at this date. Rapid and certain railway transit has effected no less complete a revolution in cost of production. Prior to the advent of the railway to Cobar in 1891, the Company was dependent on teamsters for freightage to and from the mine, and the latter again were entirely dependent upon the seasons. During a drought in 1882–3, it was found almost impossible to maintain the necessary supply of firewood, whilst the stock of copper in the sheds at the mine increased to over 1,200 tons, owing to the impossibility of transport by team over 300 miles of drought-stricken country to the nearest railway.

The water supply at this period became so restricted that armed patrols guarded the only available tank, and doled out a scanty allowance to the residents. Travellers were allowed but one drink for themselves and horses.

Significant of the changed conditions is the fact of continuous operations during subsequent disastrous and protracted droughts.

Cobar, like Broken Hill, affords a striking object lesson of the vital influence which mining exerts on the material progress and prosperity of a country. What other industry can compete with the rapidity of the restless energy with which it overcomes tremendous difficulties and reclaims arid tracts to civilisation?

During the operations of the Company from 1876 to 1893, 213,182 tons of ore were raised, and 23,610¾ tons of copper produced.

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COBAR MINING DISTRICT—*continued*.

Geological and Descriptive.—In 1880 the Writer accompanied the late L. H. G. Young, Geological Surveyor, to Cobar. From the report published by the latter (Ann. Rept., 1880, p. 262), the following notes are extracted :—

"The workings are on what is known as the west lode. On the surface there appear the outcrops of two adjacent parallel lodes. It is my opinion, however, that all three form one lode, being only separated by pieces of country known to miners as 'horses.'

"The characteristic point in the Cobar Mine is the great variation in the width of the lode, namely, from a mere film to 100 feet. . . . . .

"The ore from the 50-fathom level is composed of solid yellow sulphide of copper; from the 39-fathom level, of carbonates, metallic copper in films, red oxide, grey sulphide and brown iron ore, the lode being fairly compact.

"At the 26-fathom level the ore is principally carbonate of copper, mixed with iron ore, while the lode is less compact."

The physical features of Cobar may be briefly described as a monotonous stretch of level country, above which a few hills and ridges of low elevation rise conspicuously. Cobar lode forms a low ridge, having a north and south trend. Fort Bourke and the Peak ridges, of greater elevation and length, have parallel trends south and east of the former. The country consists of sandstones and slates of probably Silurian age. On the Geological Map of the State, the elevated peaks have hitherto been coloured as Devonian, but from the Writer's observations, and the identification of Silurian fossils by the Palæontologist, Mr. W. S. Dun, in similar rocks at Bobadah, and also in the limestone between Cobar and Nymagee, as well as the extreme lithological contrast between the highly cleaved and folded rocks, and the outliers of approximately horizontally-bedded sandstones and conglomerates—noted particularly between Mount Hope and Euabalong, and at Mount Boppy—it is more than probable that the Cobar rocks are older than Devonian.

Confirmation of the Devonian age of the upper beds in the Mount Boppy district has recently been obtained through Mr. Johnson, analyst to the Mount Boppy Gold Mining Company, who procured for the Writer a collection of Marine Fossils of that age, from between Mount Boppy and Hermitage Station.

To the north-west of Cobar, on Mount Grenfell Station, Mr. C. A. Chesney, C.E., also obtained undoubted Devonian marine fossils, but the site has not yet been geologically examined. It will probably prove an outlier similar to those already alluded to.

The elevated areas at Cobar are the direct result of mineralisation, the indurating influence of which has rendered them less amenable to subaerial disintegration and degradation than the surrounding country. This feature possibly lessens the prospect of any extensive metalliferous deposits occurring in the level country. The principal indurating agencies in the high metalliferous areas are silica and iron. Infiltrated masses of the former are conspicuous at Fort Bourke Hill, where massive sandstones have been converted into quartzite by the investing silica. The slates of these regions are highly ferruginous.

Outcrop.—Contrary to the general idea, the Cobar copper lode did not make a really strong outcrop. In only one place, near the site of the native

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well, did copper ores show at surface. Three small patches of iron oxide were exposed—two near the well, the third at the site chosen for "Renwick's Shaft." The outcrop consists chiefly of highly ferruginous slate, which, in the case of the "middle" and "eastern" lodes (2½ and 4½ chains east of the main lode) is highly silicified. The "middle" lode only has been pierced below ground in a crosscut extended 140 feet from the 54-fathom level at the north end of the main workings, and also from the 34-fathom level near Becker's Shaft. Twenty-one feet of mineralised slate in one instance and 30 feet in the other were passed through, constituting good concentrating lode stuff (yellow copper ore).

In 1885 horizontal drill bores of 330 and 238 feet were also put in east from the 39-fathom levels, in sections 16 and 19, in search of the parallel eastern lodes, but nothing more than 10 or 11 feet of quartz, at a distance of 200 feet east, was encountered in the slate country. Possibly blanks occur as in the main lode.

The comparatively small outcrops of gossan on the main lode afforded little indication of the immense ore bodies below; neither does the outcrop of the "middle" lode betray the slightest surface evidence of its cupriferous contents beneath. Hence there is reason for anticipating the occurrence of ore bodies, possibly of considerable extent in both the "middle" and "eastern" lodes, which are as yet practically intact. Both these lodes possess strong outcrops of ferruginous slate and quartz. South of the main shaft a crosscut was driven 90 feet east, but this was insufficient to reach the "middle" lode; cross-cuts at least 330 feet long are necessary to intersect the two eastern lodes.

Development.—The position of the mine, six years after the formation of the Company, is best presented by reproduction of the following extract from a report furnished to the Under Secretary for Mines by the General Manager, Mr. George Hardie[1]:—

"Three distinct lodes run through the property known as the 'east lode,' 'middle lode,' and 'west lode.' Operations thus far have been confined to the 'western lode,' upon which four shafts have been sunk—'Becker's' to 324 feet, 'Barton's' to 324 feet, 'Hardie's' to 214 feet, 'Renwick's' 286 feet.

"Becker's Shaft.—Good ores exist from the surface to the bottom. At the 26-fathom level the lode in the shaft is 24 feet wide, composed of carbonates and grey ores. At this level drives have been put in north 130 feet, and south 270 feet, proving the lode to be on an average 18 feet wide, and worth 14 per cent. At 39-fathom level drives have been put in north 90 feet and south 110 feet, the lode averaging 12 feet throughout of good ores. At the 54-fathom level the lode is proved to be at least 17 feet wide of sulphurets, worth 22 per cent.

"Barton's Shaft is 600 feet south of Becker's. At the 15-fathom level drives have been put in 191 feet, the lode averaging 15 feet of good carbonates. At the 26-fathom level drives have been put in north 180 feet, and south 161 feet—the lode throughout these drives will average 40 feet wide of grey, carbonate, and oxide ores of good quality. At the 39-fathom level drives are in north 136 feet, and south 80 feet, the lode throughout being fully 15 feet wide, with 14 per cent. At the 54-fathom level the same sulphurets precisely have been cut as in Becker's Shaft at the same level.

[1] Ann. Rept. Dept. Mines for 1878, p. 24.

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Great Cobar Copper Mine.

(90-fathom level. Massive sulphide ore in face.)

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"Hardie's Shaft, 180 feet south of Barton's, is down 214 feet, with good ore to be found in every winze and drive.

"Renwick's Shaft, 260 feet south of Hardie's, is connected with Hardie's at the 15 and 26-fathom levels, proving the existence of first-class ores. No work has been done south of Renwick's Shaft.

"Barton's Shaft is the main shaft, and is fitted with skids and cages to the 54-fathom level. A 40-horse power engine does all the hauling, works the ore breakers, also rollers for crushing fireclay, and saw-mills, etc.; and in due time will work one of Handcock's patent jiggers specially designed for treating poor ores.

"Furnaces.—There are eight furnaces in full work—six reducing, one roasting, and one refining. The present output is about 40 tons of fine copper per week. Additional furnaces are being erected with all speed.

"Tanks.—The Company has expended several thousand pounds in conserving water, and has just completed a 10,000-yard tank in addition to their previous supply.

"Output.—The output of the past year is 1,468 tons of fine copper, valued at £88,000.

"This mine has been at work three and a half years, during which period 18,993 tons of ore have been smelted, yielding 2,683 tons of refined copper (which assays 99·5 to 99·60 per cent.), valued at £160,980."

The population of Cobar at this time was estimated at 1,000.

Notes by the Writer in 1898.

The deepest shaft was 90 fathoms (540 feet). From this level drill bores were put down diagonally to a depth of 120 feet, proving a width of lode equal to 40 feet, and the ore tenor about 4 per cent. copper. Water was struck at 601 feet in the bore. At the north end the Cobar lode splits; the eastern branch made into good ore, but the western had not been followed. The working faces at the 74 and 90-fathom levels equalled 50 feet each in width, increasing in some places to 70 feet, of solid iron sulphides, containing varying proportions of copper pyrites.

The oxidized zone extended to about the 250-foot level. Though a small proportion of oxidized ores was still being obtained from this zone, the visible supply had been practically exhausted.

Winning the Ore. — Wherever possible the Cobar Syndicate adopted the contract system in stoping and trucking below ground, with satisfactory results to both parties. Drilling was practically performed by compressed air drills, though a few contract parties were still using hand drills. The contract price for mining was about 4s. per ton. The output amounted to about 2,000 tons per week. Two additional blast furnaces were being erected, for which a larger output was necessary. It, however, could not be increased beyond a moderate total, because of limited shaft room.

Though electric lighting has been installed above ground, it had not been introduced below. The adoption of ordinary coal miners' oil lamps, however, is a considerable advance on candles, both as regards light and convenience, especially for the truckers.

Haulage was necessarily comparatively slow, owing to the very restricted dimensions of the two working shafts. On reaching the surface, the loaded trucks were run to the heap-roasting ground on the east fall of the ridge, close to the shafts, and their contents dumped directly on to the heaps in course of preparation.

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Since the advent of blast-furnaces the old tips had been turned over and carefully sorted, the great bulk of the discarded material being turned to advantage, as it served admirably for fluxing purposes, yielding at the same time its quota of valuable metal. Likewise from the earlier fillings below ground, and from the walls of the lode, much low-grade, yet workable, ore was extracted, which had been discarded whilst following the richer central portions of the lodes.

Composition of the Ores.—The composition of the rich ores from the upper levels may be well studied in the following analyses made by Mr. W. A. Dixon (Ann. Rept., 1878, pp. 25–29). It will be observed that bismuth was present in marked quantity, but apparently the major portion of it was eliminated during smelting operations, as revealed by the analysis of the copper produced from the ores analysed (No. 65). It is noticeable that in a recent analysis of drillings from the 50, 74, and 90-fathom levels (sulphide zone), its presence was not detected. Possibly it may be confined to certain regions of the lode, and in the oxidized zone leaching and re-deposition may have concentrated it in appreciable quantities.

With a view of increasing the malleability of the Cobar copper, about 400 tons of Nymagee regulus were once purchased to mix with it to reduce the effects of the bismuth, Nymagee ore being practically free from this injurious associate.

On the walls of the lode a little zinc-blende and galena make at intervals, which are roughly discarded at the surface.

ANALYSES of Cobar Copper Ores, by W. A. Dixon. (Ann. Rept., 1878, pp. 25–29.)

Assay Numbers.	56	57	58	59	60	61	62	63	64	65
Silica	4·26	2·06	·62	1·92	·96	20·68	·56	10·64	20·28	.....
Copper	22·64	54·06	37·87	54·93	26·47	63·24	57·42	42·79	38·23	99·346
Antimony	·61	Traces	Traces	Traces	·46	·13	Traces	..	..	·029
Bismuth	2·11	1·47	1·90	2·58	2·17	1·18	·95	1·24	·21	·419
Lead	·27	·41	·45	.	..	..	7·79	..	..	·086
Arsenic	Traces	..	..	..	..	..	..	..	..	·011*
Iron	39·20	7·28	30·80	18·26	39·09	1·74	4·99	8·49	·78	·053
Zinc	·35	..	..	..	..	..	..	..	..	.....
Silver	Traces	Traces	..	..	..	..	..	..	..	·026=8 oz. per ton.
Nickel	..	Traces	Traces	..	..	..	..	..	..	.....
Magnesium	..	5·33	..	..	..	..	Traces	..	..	.....
Sulphur	24·11	4·18	18·63	14·48	27·46	5·70	11·67	..	..	.....
Carbonic Acid	..	9·97	..	..	..	Traces	5·87	14·87	17·47	.....
Water	..	3·41	..	..	..	..	4·90	7·04	3·79	.....
Water, oxygen (less water), loss, undermined, &c	6·25	11·83	10·00	7·83	3·29	7·83	6·15	15·48	10·24	
	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·000

* Traces of arsenic, nickel, cobalt, gold, loss, &c.

Sample 56—Copper pyrites and magnetite.
,, 57—Red oxide, copper glance, and ferric oxide.
,, 58—Copper pyrites, red oxide, and ferric oxide.
,, 59—Copper glance with ferric oxide.
,, 60—Copper pyrites and magnetite.
Sample 61—Copper glance and red oxide.
,, 62—Copper glance with malachite.
,, 63—Malachite with ferric oxide.
,, 64—Azurite.
,, 65—Copper from the above.

The nature of the sulphide ores at Cobar is partially revealed by the following analysis made in the Departmental Laboratory from drillings obtained by the Writer through the courtesy of Mr. T. Longworth, of the Cobar Syndicate. The sample was intended to represent an average of two days' drillings at the 50, 74, and 90 fathom levels; the copper contents,

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however, may be disregarded, as they do not represent the average value of the ore in these levels, which, according to the smelting returns, ranges between 3·2 and 4·4 per cent. :—

Moisture at 100° C	0·20
Metallic iron	42·65
,, copper	10·15
,, lead	trace
,, zinc	,,
Silica	16·09
Alumina	0·44
Lime	absent
Magnesia	0·34
Sulphur	20·74
Sulphur trioxide (SO_3)	0·23
Oxygen (by difference)	9·16
	100·00

Silver, at the rate of 1 oz. 21 dwt. 21 grs. per ton.
Gold, a trace (under 2 dwt.) ,,

Note—A large amount of magnetite is present in this sample.

The proportion of iron is complicated by the admixture of fragments of metallic iron broken from the drills, which could not be removed without loss of a portion of the magnetic pyrites present.

Preliminary treatment of the Ores.—Though the Cobar sulphides are eminently suitable for partial pyritic smelting, the Syndicate had not deemed the advantage to be gained sufficient to induce it to incur the cost of providing a hot blast, without which it was then considered pyritic smelting could not be efficiently maintained. This process was subsequently adopted; and later (as explained elsewhere) it was accidentally discovered that the costly hot blast was not essential, providing the air-pressure was increased.

As the ore came from the stopes, it was piled on the roast-heaps without extra care. In forming the roast-heaps the V system was roughly followed; sufficient space being left between two adjacent heaps to admit of a third V-shaped filling between, when the former were underway. A rough foundation of wood was laid down, and, in the case of the later-formed central heap, carried up the sides of the adjoining heaps. Apparently little attention was paid to flues for ventilation; doubtless the large size of the ore-blocks afforded sufficient in the cavities between them to obviate the necessity of special preparation to secure it. The heaps took an elongated form from the raised tramway used for stowing, and contained from 2,000 to 4,000 tons. A little ragging was spread on the tops, but scarcely any on the sides. The fines apparently were little used for covering, being mostly roasted separately in a circular kiln excavated in the outcrop.

The absence of sufficient covering accounted for the evidence of too great heating in parts of the roast-heaps, where fusion sometimes took place to a considerable extent. About three weeks were allowed for a roast (according to Mr. T. Longworth, the managing shareholder). The roasting heaps were well situated on sloping ground, which afforded excellent drainage. The natural aridity of the climate disposed of the necessity for provision being made for recovery of copper carried away as soluble salts from roast-heaps during rainy weather.

Owing to the long campaign with reverberatory furnaces at Cobar, the country has been devastated of suitable firewood for a radius of many miles. The wood required for heap-roasting cost 15s. per ton for dry 5-foot lengths, and 12s. 6d. for green. The consumption of firewood in the reverberatory

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furnaces averaged about 70,000 tons per annum. In 1889 a trial was made with coal from one of the top seams of the Dubbo Coal-field (Ballimore ?). Mixed with wood, it answered fairly well in a reverberatory furnace, and about equally as well mixed with charcoal in the blacksmith's forge.

(The Great Cobar, Limited, has now decided to use Lithgow coal for firing.)

Smelting.—The furnace charges consisted generally of the following proportions :—

8 cwt. of raw sulphides.
8 ,, of calcined sulphides.
4 ,, of oxidised ores, slate, dry gold and silver ores, &c.[1]
4 ,, of coke.

The first reduction brought the matte up to about 30 to 35 per cent. tenor, in which form it was sent to the Syndicate's roasting and refining plant at Lithgow, where some sixteen reverberatory furnaces are in use.

The smelting-plant at Cobar consisted of four 80-ton water-jacketed blast-furnaces, with a working capacity of about 120 tons per twenty-four hours, but it was announced that two additional furnaces were to be erected.

Gold in Cobar Copper Ores.—Though gold was early known to be present in the Cobar Mine, and in the free state was occasionally noticed in the oxidized ores, no attempt was made to turn it to account until the Cobar Syndicate began operations in 1893–4. In 1882 Mr. Russell Barton secured a specimen of malachite showing coarse gold, and the Company's caretaker (the late Mr. W. Gillard) had in his collection a specimen of slate from near the outcrop containing a rich seam of scaly gold.

In 1881 an assay was made in the Departmental Laboratory of a sample of the Cobar copper obtained by boring through several ingots, with the following results :—

Gold	2 oz. 12 dwt. 4 grs. per ton.
Silver	1 ,, 5 ,, 0 ,, ,,
Copper	92·65 per cent.

As these results were made known at the time it appears strange that no advantage was derived from the knowledge. Cobar copper, for years, must have proved a lucrative investment for metal-buyers in England, who secured it at a lower market rate than Chilian bars, notwithstanding its valuable gold contents. Possibly the difference in market value between the Cobar and Chili metals was sufficient to defray cost of further refining, leaving the precious metal as clear profit. Mr. Russell Barton (at one time Chairman of the Company) attributes the omission to the fluctuating results of tests of the surface ores, portions of which gave fair gold value, others almost negative results, a natural outcome of the leaching and re-precipitating processes to which the upper levels of the lode had been subjected. As gold is less susceptible to natural leaching solutions than copper, it remains to enrich the more gossany ores from which the copper had been wholly or in part removed. The re-precipitated or secondary copper ores would thus become richer and more concentrated, but impoverished in gold, hence the fluctuating returns of assay samples, which appear to have depreciated the importance of the presence of gold, even in small quantities, in the ores, notwithstanding the well-known collective influence of metallic copper on the precious metals in smelting. Mr. Barton states that the gold contents of the copper produced during early operations varied from half an ounce to 3 oz. per ton. Not till the latter half of 1894 did the Company draw

[1] When slag from the forehearths was used—about every second charge—it took the place of this item.

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the attention of buyers to the presence of gold and silver in their copper in recoverable quantities. The immediate result was an advance of about £7 per ton over the current quotations for Chili bars.

The sulphides from the working stopes in 1898 were reported to yield from 2¼ to 3 dwt. of gold per ton. Concentration at the present day is extreme compared with past operations, and probably the average proportion of gold in the sulphides, though lower, is more constant and even than was the case in the oxidized ores. In smelting 10 to 20 and even 30 per cent. ores, concentration is very slight compared with smelting ores of a 2 or 3 per cent. tenor, hence the gold and silver contents are considerably higher in the metal produced from the latter. The market value of the Cobar copper is now enhanced some £20 odd per ton by the contained gold and silver. This great enrichment is not due, however, solely to concentration of the indigenous gold of the Cobar Mine, for the quantity is augmented by use of gold and silver ores from other mines as fluxes in the blast-furnaces; and herein lies the great potentiality of the pure iron and copper sulphides of Cobar; their importance as fluxing bases for dry (silicious) gold and silver ores cannot well be over-estimated. At the Peak, about 5 miles south of the copper-mine, the Cobar Syndicate secured a gold and silver mine (Conly and Barrass'), and worked it in conjunction with the former. The better class of gold ore was treated in a battery locally; the lower grades, which, however, were fairly rich in silver—containing about 30 oz. per ton and 3 dwt. of gold—were carted to the smelting furnaces for fluxing purposes. The Peak lodestuff consisted of soft rotten slate, with harder cherty bands and quartzite; in the ferruginous joints and cavities silver-chloride was freely visible.

The sulphides of Cobar consist largely of pyrrhotite (magnetic pyrites composition Fe_7S_8 = iron = 60·5, sulphur = 39·5), with pyrite, and chalcopyrite (composition Cu_2S, Fe_2S_3 = iron = 30·5, copper = 34·6, sulphur = 34·9) equivalent to a smelting return of about 3¾ to 4½ per cent. of copper. They are comparatively very low in silica—16·09 per cent.—according to the analysis of the drillings already quoted; though not approaching the unique purity of Mount Lyell ore in this respect. The importance to the field of the low percentage of silica in the immense sulphide deposits of the Cobar Mine is very great, as it affords a cheap and efficient means of extracting the gold and silver contents of the ores of some of the neighbouring mines, especially those in which copper occurs too sparingly for separate metallurgical treatment, yet too pronounced for ordinary battery or cyanide processes. Silica is necessary in the furnace charge to combine with the abundant iron of the sulphides to form a fluid silicate of iron slag. The silicious gold and silver ores of the adjacent mines are just what is requisite for proper fluxing requirements. According to Dr. Peters,[1] Junr., a silicious schist or slate in itself is preferable to pure silica (quartz) in matte roasting and doubtless also in reducing. The advantage to a smelting company of being able to command silicious flux having of itself intrinsic value is immense, whilst an equivalent benefit is derived by the owners of such ores. In some public smelting works a mutual gain is derivable from payment of the actual value of the gold and silver contents of dry silicious ores, without deductions other than freight, in return for the necessary flux thus obtained almost free of expense.

[1] Modern Copper Smelting, 5th ed., 1892, p. 271.

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The proper proportion of silica in blast-furnace slag, according to Dr. Peters (Modern Copper Smelting, 5th edition, 1893; p. 185), lies between 24 and 36 per cent., and may be raised or lowered about 6 per cent. without seriously affecting the running of the furnace, but every unit in excess will reduce the amount smelted in 24 hours. Assuming that the maximum limit —36 x 6 = 42 per cent.—could be observed without serious inconvenience, and it is well known that this limit is sometimes, but not optionally, exceeded, Cobar ores could carry a considerable addition of silicious flux. The above authority in the 7th edition of the same work, p. 282, states that "probably the most silicious slag made regularly in the world in blast furnaces is that of the Saengerhausen Smelter on Mansfeld ores of Prussia viz., 53·83 per cent. of silica."

Robert Sticht, in an article on pyritic smelting contributed to Peters' Modern Copper Smelting, 7th edition, p. 402, states that "the amount of silica in the slags may vary from below 28 to above 48 per cent., to suit the ores treated." Hence with pyritic, or partial pyritic, smelting at Cobar, the amount of silicious flux may be largely increased, especially if in addition the amount of sulphur be so regulated as to avoid the formation of excess of protosulphide of iron in the matte, leaving the protoxide of iron free to combine with the silica, instead of with the excess of sulphur, over and above the amount required to satisfy the copper. The proportion of sulphur to copper in subsulphide of copper is 1 to 4, whilst that of sulphur to iron in ferrous subsulphide is 1 to $1\frac{3}{4}$.

Herbert Lang[1] states that "slags have been and are being made in practice which contain as much as 65 per cent. of silica." In reverberatory furnaces a high proportion of silica can be slagged off.

Progress of Development since 1898.—Mine purchased in 1900 for £500,000 by the Cobar Syndicate, which had been working it for seven years on tribute.

1902.—Naismyth slag-pots introduced; capacity 2 tons, drawn by horses. Additional air-compressor machinery installed, also new blast furnace.

1903.—New furnace started; capacity, 300 tons per day, against 66 in old furnaces. Large furnace of Mount Lyell type purchased. Slag-pots removed by locomotive in trains of six.

New main shaft begun.

1904.—Cobar-Chesney Mine purchased; ore smelted with the Cobar; about 27 per cent. being used as flux for the basic sulphides of the latter. Ore-breaker erected; capacity, 120 tons per hour.

New furnace started; measurement, 17 feet 4 inches x 3 feet 8 inches at tuyeres. Barton's Shaft deepened from 980 to 1,050 feet; level opened at 1,000 feet.

Maximum length of proving, 1,000 feet; men employed, 525.

1905.—Option to purchase given to an English company at end of year.

Smelting plant—three furnaces—capacity, 250 to 380 tons daily. Samuelson's Roots-Blower, pressure 22–24 oz. per square inch. Hot-blast abandoned in favour of cold under increased pressure.

1906.—Mine and associated properties (with exception of Nymagee) acquired by an English company—the Great Cobar, Limited—for £800,000 cash.

[1] Matte Smelting, 2nd ed., 1898, p. 37.

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COBAR MINING DISTRICT—*continued*.

The Cobar Syndicate's properties transferred being the Cobar Mines and plant, Lithgow refinery and electrolytic plant, and associated colliery, and colliery and coking ovens at Rix's Creek, near Singleton.

New main three-compartment shaft, 15 feet x 7 feet 6 inches, being sunk on east side of lode to 1,000-feet level. Barton's Shaft, 1,000 feet, equipped with first-motion winding-engine.

Large blast furnace erected; two blowers added to plant. Foundations for three furnaces of large capacity, and for converter plant, begun.

When new main shaft—which was started at several levels simultaneously—is available, the daily output will be increased from 400 or 500 to 1,500 tons.

1907.—New plant being installed; 964 men employed in mine and works.

Mining Development.—The most important features of the latest mining development in the Cobar lode are improved width, and sustained values in the lowest levels. At 1,000 feet a crosscut had penetrated 102 feet of ore up to 8th July, 1908.

At the north end, too, at 800 feet, in the lowest working level in that direction, values have improved beyond the upper poor zone, where a basic mixture of pyrite with zinc and lead sulphides, contains not more than 1 per cent. of copper.

The inference deducible from developments at 1,000 feet—that values have become constant, is supported by the average annual grade of production since the oxidised ores were exhausted.

The percentages since inception of partial pyritic smelting in 1905, afford instructive study, showing gradual depreciation from 4·42 in 1905 to 2·35 in 1903. For the ensuing four years the grade remained practically constant, viz., 2·49, 2·42, 2·87, and 2·48.

Though these results are complicated by admixture each year of the product of several levels (as well as the Cobar-Chesney quota); still, as the higher are usually exhausted first, they may be regarded as fairly indicative of the rate of vertical depreciation.

Though copper lodes, in common with other metalliferous bodies, show marked depreciation in value with augmenting depth, a limit to depreciation appears a natural corollary to enrichment consequent on superficial decomposition, leaching, and redeposition at lower levels.

The Cobar lode consists of three lenses extending in a N. 10° W. direction, with a slight dip to the east.

The "Centre" or principal lens, which is shown in the following cross section, has an average length of about 450 feet, and a width of about 70 feet (the maximum being 120 feet at the 800-foot level).

The "North" lens is separated from the "Centre" by a blank of 140 feet. Its length, so far as proved, is 300 feet, and its width 90 feet.

The "South" lens is separated from the "Centre" by a blank of about 50 feet in the upper levels, but merges into it below No. 3 level. Its width averages 50 feet; the maximum being 75 feet in No. 7 level, and its greatest length 150 feet.

South of this lens, the ore dies out in country, though slight metal values and quartz leaders continue in the rubbly channel slate.

The ore lenses are simple impregnations and replacements in slate and fine sandstone, with more or less quartz in places. Iron and copper sulphides make solid for the most part, but are occasionally mixed with slate and quartz. The north lens being especially basic even where low in copper.

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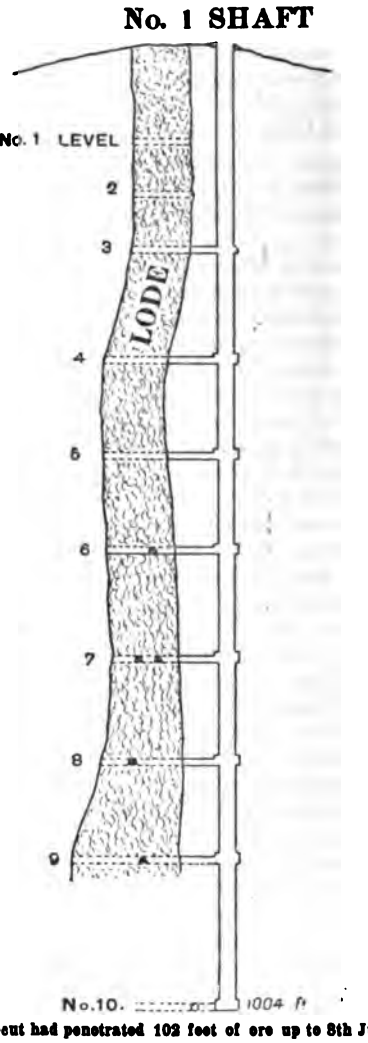
GREAT COBAR COPPER MINE

CROSS SECTION OF LODE

Scale 0 100 200 Feet



(No. 10 cross-cut had penetrated 102 feet of ore up to 8th July, 1902.)

No true walls exist, the ore dying away gradually in the country, and in the blanks between lenses. A marked distinction, however, is noticeable between the channel slate and the west country, the latter being more jointed and blocky.

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Great Cobar Copper Mine.

(90-fathom level. Lode, 70 ft. wide.)

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Mr. J. D. Kendall, Consulting Engineer of the Cobar, Limited, estimated the ore *in sight* on the 31st December, 1907, as follows :—

In the Great Cobar Mine	.....	1,400,000 tons.
„ Chesney	„	499,999 „

Accompanying these figures with the following note :—"Although in the above figures the ore in the middle shoot has only been calculated to 75 feet below the 850-foot level, it should be stated the ore body has actually been proved at the 1,000-foot level to fully maintain its width and values."

Description of the New Plant being installed by Great Cobar, Limited.—By G. H. Blakemore.—The alterations and new plant on the Great Cobar Mine have been of an extensive nature. The total cost has exceeded £160,000. A brief description of the alterations is as follows :—

"A new main shaft, 15 feet 5 inches x 8 feet over all dimensions, has been sunk from the surface to the 1,000-feet level. It is divided into three compartments, two of which are for hauling, and one to contain pump-pipes, air-pipes, and ladder-way. The size of the hauling compartments is 7 feet 6 inches x 4 feet 6 inches inside diameter, and the pumping compartment is 7 feet 6 inches x 5 feet 1 inch. The shaft is equipped with a winding engine, made by Andrew Barclay and Sons. It consists of a pair of coupled horizontal non-condensing engines, cylinders 22 inches diameter x 48-inch stroke, governed by Corliss valve gear, Dash-pot release type. The drums are 10 feet diameter, grooved faces, one drum fast and one loose, width 4 feet. The loose drum is fitted with Hall's patent friction clutch, for throwing in or out of gear. The engine is fitted with steam brakes, as well as hand brakes ; its capacity is a winding speed of 2,000 feet per minute, with a load of ore of 2 tons. The ore, as it is delivered at the surface, will be crushed to a 4-inch ring, through an Hadfield rotary crusher, capable of crushing 120 tons of ore per hour. There are two of these crushers, each driven by 100-horse-power electric motors. The crushed ore will deliver from the breakers into a Babcock and Wilcox tray conveyor, which in turn will deliver into a small storage bin. From this storage bin the ore is drawn off into bogie wagons, each of 30 tons capacity, and hauled by electric locomotives to storage bins of, approximately, 2,000 tons capacity. From these large storage bins the ore is dropped into Pooley patent scales, which weigh out the charge required for the blast furnace. There are twenty-four of these scales fitted to the bins. From the scales the ore is dropped into 2-ton wagons, which will be hauled on to the furnace floor in sets of three or six by an electric winch developing about 75 horse-power. The ore will be hand-dumped into the furnaces. The furnaces stand on brick and concrete base 9 feet high from the ground. Each furnace is 56 inches wide by 240 inches long inside at the tuyeres. There are twenty tuyeres on each side, making forty in all. The inside diameter of the tuyere at the nose is 5 inches ; centre to centre of tuyere, 12 inches. The bottom of the furnace is a thick cast-iron base, which stands 3 feet 7 inches above the top of the brick and concrete foundation. The centre of the tuyeres above the brick base is 6 feet 7 inches, and the charging floor is 27 feet 6 inches above the top of the brick base. Each furnace is water-jacketed for a height of 17 feet above the centre of the tuyeres.

"There are ten lower-side jackets, two lower-end jackets, ten upper-side jackets, two upper-end jackets. The end section of the furnace is vertical ; the side section shows a bosh of, approximately, 7 inches in the length of the lower-side jackets, which are 10 feet long. The top jackets are 9 feet 11½ inches high.

"There are three such furnaces installed. With the three furnaces are four separators, so arranged that any one furnace can deliver the slag and matte

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into two separators. Each separator is 18 feet diameter and 4 feet 6 inches deep, circular in shape, made of $\frac{5}{8}$-inch steel plate, having one slag overflow and two matte tap-holes. All the slag and matte from the blast furnace will deliver into these settlers. The slag will overflow into pots of a capacity of 25 tons, which will be hauled to the dump by an electric locomotive, and there emptied of their contents by being turned with an electric motor. The matte is tapped into ladles of a capacity of 10 tons, which will be picked up by a 40-ton electric crane, and poured into 15 tons capacity converters.

"The furnaces are each supplied with a separate blower, of a capacity of 36,000 cubic feet of air per minute, at a pressure of 42 ounces per square inch. These blowers are coupled to separate engines made by Cole, Marchent, and Morley. They are compound tandem horizontal engines, fitted with Morley's patent drop valve gear, actuated by a lay shaft and eccentrics. The cylinders are 15 inches and 22 inches diameter by a 36-inch stroke. Each engine is capable of developing 540 indicated horse-power at 100 revolutions per minute, with a steam pressure of 172 lb. per square inch.

"The blowers are arranged in such a fashion that the wind from any blower can be delivered to any furnace. The capacity of each furnace is expected to be about 500 tons per day.

"The converters are blown with air, provided from a single stage blowing engine, made by Walker Bros., of Wigan, England. This engine is a horizontal cross compound of steam, cylinders 18 inches and 38 inches, with 48-inch stroke. The air cylinders are 42 inches diameter. The steam valves are spring Corliss gear, with Walker Bros.' patent air valves on the air end. The capacity of the engine, at about 90 revolutions per minute, is 12,000 cubic feet of free air per minute at 15 lb. pressure.

"All these engines and blowers are contained in one engine-house, together with the following machinery:—Two air compressors, by Walker Bros., of Wigan, each of which are horizontal cross compound two-stage air-compressing engines, fitted with spring Corliss valve gear, with double eccentrics, the air valves being Walker's patent. The steam cylinders are 16 inches and 34 inches, the air cylinders are 19 inches and 31 inches, and the stroke is 42 inches. The approximate capacity of each is 3,000 cubic feet of free air at 80 lb. pressure, with a steam pressure of 170 lb.

"The electric installation in the same building consists of three sets of engines and alternators, together with one direct current converter for transforming alternating current, the transformed current to be used for lighting and part of the power service.

"The alternator engines are made by Browett and Lindley. They are triple expansion high speed vertical engines, cylinders being 12½ inches and 17½ inches and 26 inches respectively, with a 12-inch stroke; speed, 375 revolutions per minute. These engines are each direct-coupled to a Siemens 300 K.W. 3-phase A.C. generator to operate at a 440-volt circuit. The direct-current converter mentioned above is driven by a Siemens induction motor; the direct-current generator output is 1,040 ampères at 250 volts. This current is used on the Converter Motors, Electric Locomotives, Winding Winch, and for light. The current is transformed down to 110 volts on the lighting circuit, and there are step-up transformers where required, to bring the current up to 3,000 volts.

"The steam for this plant is supplied by six Babcock and Wilcox water-tube boilers, each capable of developing 450 indicated horse-power at 170 lb. of steam, and the boilers are fitted with chain grate stokers, superheaters, and Green's economisers.

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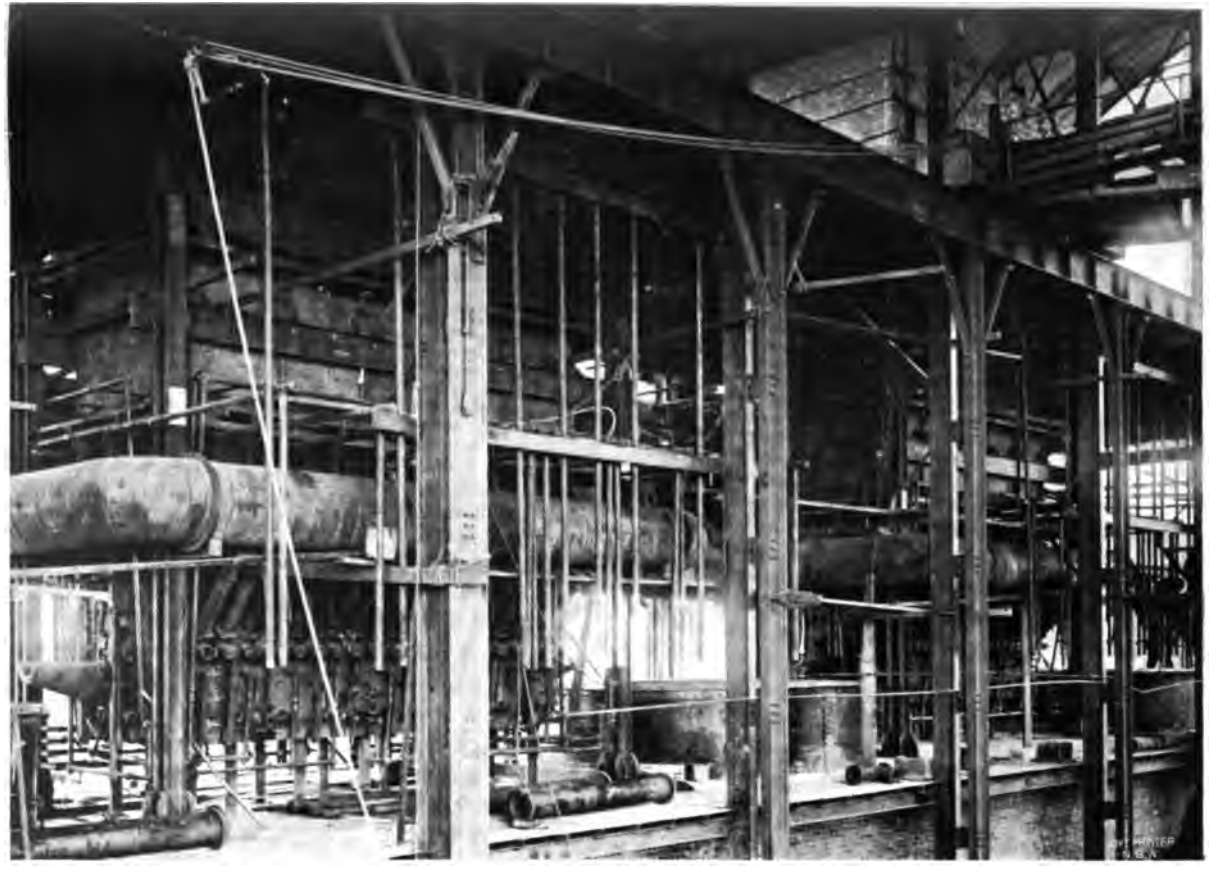

H. Lowell Price.

Great Cobar Copper Mining Company.

(Interior View of Smelter Building, showing Furnaces and Settlers nearing completion.)

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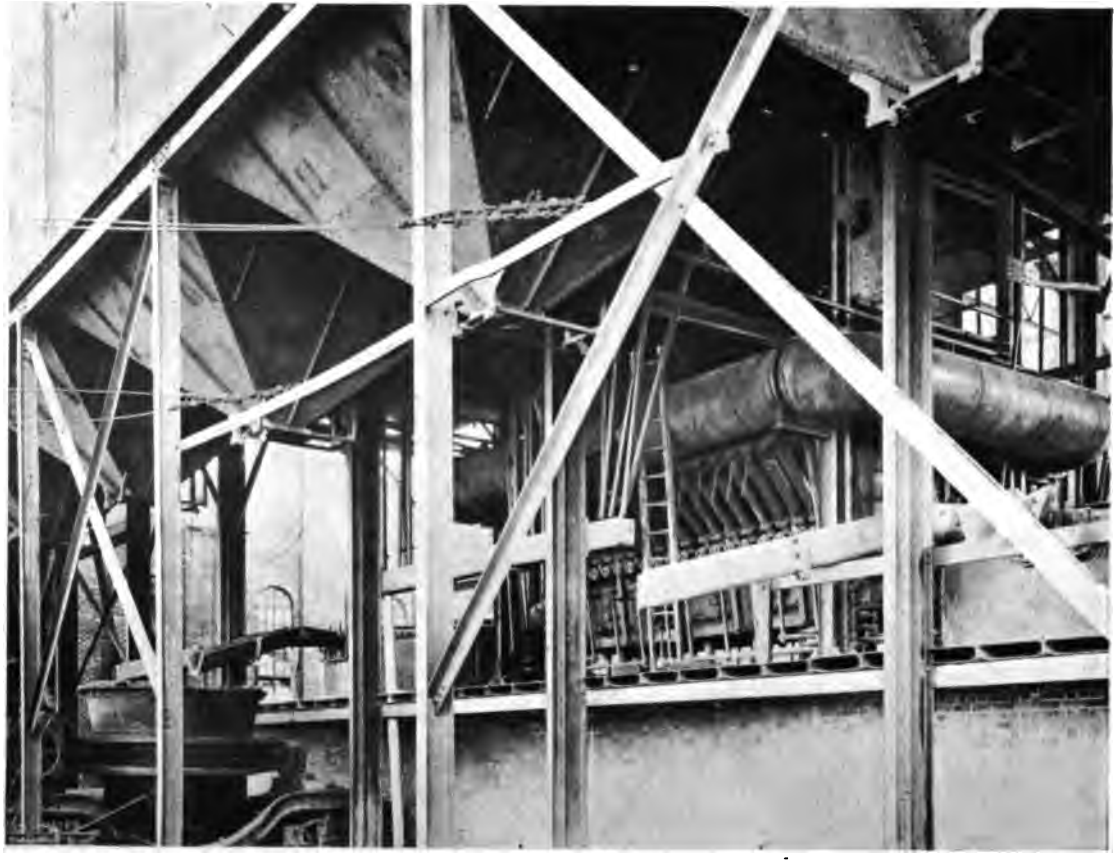

H. Lowell Price.

Great Cobar Copper Mining Company.

(Elevation of No. 1 Blast Furnace, showing slag spouts from Nos. 1 and 2 Settlers, and Slag Car.)

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COBAR MINING DISTRICT—*continued.*

"The smoke from the blast furnace delivers out into a flue, the bottom of which is all hoppers. A settling chamber is arranged in the course of the flue, the bottom of which also consists of hoppers. The flue dust will be easily withdrawn in this way. The smoke finally is thrown into the air through a steel chimney, which is approximately 196 feet 6 inches high and 14 feet inside diameter at the top. The boiler smoke is also drawn off by this chimney.

"The installation of this plant will stop the further despatch of matte to Lithgow. Instead of matte being sent, copper in the form of "blister" will be despatched in the shape of cakes weighing about 2 cwt. These will be refined at Lithgow in the anode furnaces, and the gold and silver extracted as before by the electrolytic plant."

OUTPUT of the Cobar Copper Mine (and Cobar-Chesney from 1904).

Half-year ended—	Ore.	Equal to Copper.	Percentage.	
	tons.	tons.		
31 Dec., 1876	1,458	174	11·93	
30 June, 1877	2,350	255	10·85	
31 Dec., 1877	2,530	268	10·59	
30 June, 1878	3,651	600	16·43	
31 Dec., 1878	4,738	857	18·08	
30 June, 1879	5,610	876	15·61	
31 Dec., 1879	7,005	1,015	14·48	
30 June, 1880	8,334	1,181	14·70	
31 Dec., 1880	11,890	1,388	11·67	
30 June, 1881	9,930	1,163	11·71	
31 Dec., 1881	11,622	1,405	1·208	
30 June, 1882	5,882	942	16·00	
31 Dec., 1882	5,820	863	14·82	
30 June, 1883	6,772	955	14·10	Produced by the Great Cobar Copper Mining Company.
31 Dec., 1883	11,324	1,460	12·89	
30 June, 1884	11,876	1,361	11·46	
31 Dec., 1884	12,003	1,408	11·73	
30 June, 1885	11,558	1,064	9·20	
31 Dec., 1885	12,000	1,066	8·88	
30 June, 1886	14,000	1,093	7·80	
31 Dec., 1886	11,887	951	8·04	
30 June, 1887	10,840	888	8·01	
31 Dec., 1888	9,000	705	7·83	
30 June, 1888	5,500	416	7·56	
31 Dec., 1888	7,425	589	7·09	
*3 Aug., 1889	8,177	667¾	8·15	Eight months' output.
1895	38,278	1,694	4·42	
1896	63,185	2,708	4·09	
1897	64,262	2,492	3 87	
1898	111,557	3,424	3·06	
1899	123,834	3,746	3·02	
1900	114,465	3,475	3·03	Produced by the Great Cobar Syndicate.
1901	110,767	3,206	2·89	
1902	89,634	2,415	2·69	
1903	141,781	3,333	2·35	
†1904	143,244	3,580	2·49	
1905	180,538	4,061	2·24	
To 21 Aug., 1906	108,032	3,108	2·87	
From 22 Aug. to 31 Dec., 1907	237,916	5,916	2·48	17,130 oz. gold, 98,769 oz. silver; produced by Great Cobar, Limited.
Total	1,749,675	66,768	3·83	

* Eight months' output. † From 1904, Cobar-Chesney output also included.

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Cobar Mining District—*continued.*

Analysis of Great Cobar E.L.C. Copper by Messrs. Dixon and Byrn, Analysts, 97, Pitt-street, Sydney.

Gold	0·0001	per cent.
Silver	0·0013	,,
Antimony	Nil.	
Arsenic	0·0010	,,
Lead	0·0009	,,
Selenium	Trace.	
Telurium	Nil.	
Bismuth	0·0018	,,
Zinc	0·0018	,,
Nickel	0·0031	,,
Oxygen	0·037	= (suboxide of copper, 0·3317.
Copper	99·95462	(by difference).
	100·00000	

Conduction of sample according to Mr. G. H. Blakemore was 100·3 per cent. by Matthiessen's standard.

The following returns of gold and silver from the Great Cobar Mine, from 1898 to 31st December, 1906, including the Chesney Mine output from 1904 to 1906, and presumably the Peaks Gold and Silver Mine whilst working, as well as purchased ores at Lithgow, were kindly supplied by Dr. Richard Read, managing director of the Cobar Syndicate :—

Year.	Gold.	Silver.
	oz.	oz.
1898	16,215·	145,664·753
1899	13,698·004	59,586·517
1900	8,899·815	60,366·378
1901	7,252·815	52,335·655
1902	3,097·0	16,933·5
1903	11,078·055	40,402·501
1904	9,495·0	57,635·15
1905	9,159·875	53,206·599
1906	11,757·48	78,521·823
	90,652·8	564,652·8
Jan. 1 to Aug. 22, 1907*	7,566·	†50,536·
Aug. 23 to Dec. 31	17,130·	‡98,769·
Total production	115,348·8	713,957·8

* Estimated on the rate of the previous year's output.
† To date of transfer. ‡ Produced by Great Cobar, Limited.

Accompanying the above returns was the following note by Dr. Read :—"From 1898 to 1901 the copper was sold as auro-argentiferous material. During 1901–2 the electrolytic works were established at Lithgow, and all the gold and silver separated in them, the copper being shipped as electrolytic copper. The small quantity of gold and silver returned for 1902 is accounted for by an accumulation of untreated auro-argentiferous deposit in the vats during that year."

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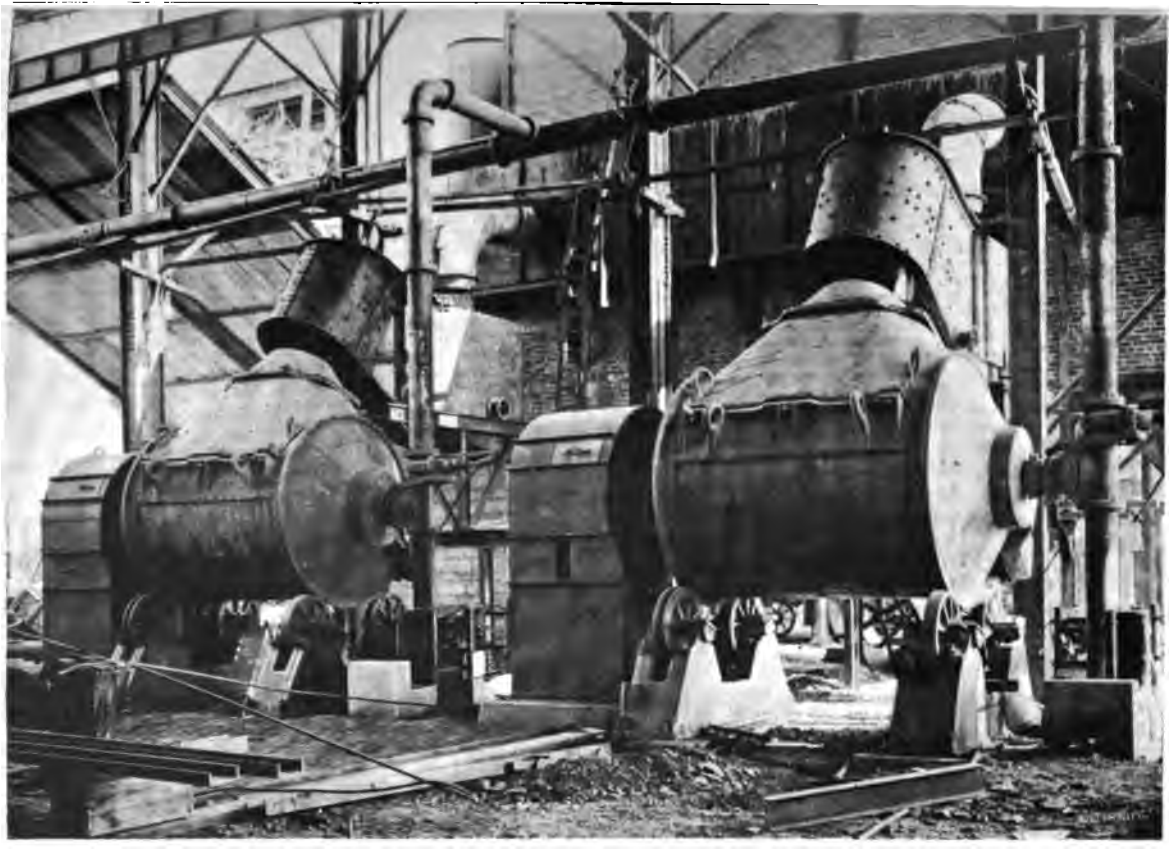

H. Lowell Price.

Great Cobar Copper Mining Company.

(Nos. 1 and 2 Converter Vessels on blowing stands, with movable hoods, leading to dust chamber at back.)

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COBAR MINING DISTRICT—*continued.*

The southern portion of the Great Cobar lode was originally floated as the Southern Cobar Copper Mine. The following notes are printed as a record:—

Taken up by Joseph Becker in May or June, 1871, adjoining the Cobar Mine on the south. Worked by the Southern Cobar Copper-mining Company Limited, until January, 1876, when the two mines were amalgamated under the title of the Great Cobar Copper Mine.

Renwick's Shaft, frequently mentioned in the reports of the Great Cobar Company, formed the main shaft of the Southern Company. It was sunk within about 40 feet of the south boundary of the Cobar property.

Though this mine became so early incorporated with the main mine, it is interesting to regard it separately up to the time of amalgamation, as the prospecting operations therein have an important bearing on the prospects of the southern continuation of the Cobar lode, in which direction work is not now proceding.

The Southern Cobar Company was floated with a capital of 80,000 shares of £1 each.

The following particulars have been extracted from the half-yearly reports of the Company:—

Fourth Half-yearly Report, 26th August, 1874.—Main shaft 40½ fathoms, lode 20 feet wide. Preparations for two furnaces being made.

During the half-year 220 tons of good ore raised, and 150 tons despatched from the mine. The quality of the ore can be judged from the following account sales from Adelaide:—

Tons.	Assay per cent.	Net return. £ s. d.
15	40¾	294 18 10
58	35¾	1,204 2 4
22	26⅝	
14	27⅜	305 2 4
8	43⅛	
5	44⅝	109 16 6
12	38¼	243 3 5
4	26⅜	
13	36¾	231 9 3
15	37⅛	610 4 9
4	26¼	
14	42¼	
3	43	63 5 1
23¼	44	542 7 4
30⅛	42	671 14 9
6½	43½	150 16 5
18	42⅝	475 3 1
12⅛	39½	264 4 8
		£5,166 8 9

During the half-year ending 31st December, 1874, the main shaft was deepened to 46 fathoms. At 35 fathoms the lode was cut in a cross drive west 122 feet from the shaft, and was found to be only 7 inches thick. A winze sunk, following the lode from the 25-fathom level to the 35-fathom, proved it small and unprofitable.

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Operations during the sixth half-year were confined to raising ore from the 15 to 25 fathom levels, and to prospecting. No ore was obtained in either the 35 or 45 fathom levels.

At the 35-fathom level the lode channel was driven on 247 feet north, 24 feet of which alone bore stains of copper. The lode varied in width from 3 inches to 3 feet, consisting principally of slate (in some places quartz), strongly stained with iron.

At the 45-fathom level the lode, intersected in a crosscut west 176 feet in length, was contracted to a mere division in the strata, showing no signs of copper.

During the first half of 1875 two smelting furnaces were completed and a third begun; 316 tons of ore were smelted, yielding about 45 tons of coarse copper; ore at grass valued at £3,945.

Great Cobar North Mine, adjoining the Great Cobar Copper-mine on the north. Prospected by the original North Cobar Company, by three shafts along the strike of the Cobar lode, close to the boundary, without, however, disclosing workable ore, though a little lean ore was struck in No. 3 shaft.

Later, for some unaccountable reason, a shaft was sunk 500 feet west of the strike to a depth of 520 feet, and a crosscut started east from the 500-feet level.

In 1906 the property was reported to have been purchased by the present Great Cobar North Copper-mining Company, Limited, on the strength of surface indications of a strong lode below, discovered (?) by the electric ore-finder.

The West Shaft was thereupon unwatered, and the crosscut extended 605 feet, or 100 feet east of No. 3 shaft on the Cobar strike, without encountering any more favourable indications than previously disclosed by the strike shaft.

The latter was connected by a rise from the tunnel level, and a winze sunk 40 feet below it (at date of inspection in October, 1907).

For a width of 22 feet west, including the shaft, slate, with leaders of quartz, carries copper pyrites very sparingly. The winze was sunk in the best portion, where more copper sulphide was developed for a width of about 2 feet, a sample of which is reported to have assayed 4 per cent. Four feet of similar lodestuff was reported at the bottom of the winze, but water prevented close inspection of the lower part; a little galena is also associated with the copper sulphide. A small sample of picked clean ore from the lode-stuff raised in sinking the winze assayed:—

No. 07-7425—Copper, 8·70 per cent.
Gold, a trace
Silver, 15 dwt. 6 grs. } per ton.

An average sample of all the material raised from the 22-feet crosscut in mineralised lodestuff and the 40-feet winze yielded:—

No. 07-7424—Copper, 0·25 per cent.
Gold, a trace
Silver, 4 dwt. 8 grs. } per ton.

The strike of the orey belt was driven on 62 feet north, without, however, disclosing any metal values. To the south of the shaft, which is 24 feet south of the crosscut from the west shaft, a drive has been extended 31 feet in a blank, no ore showing in face.

It is proposed to deepen the shaft to 1,000 feet. The hope of this venture depends on the continuance of developments of a payable character in the

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lower northern extensions of the Great Cobar workings. If these continue to the boundary, there are possibilities about or below 1,000 feet in the North Cobar Mine.

Great Eastern.—Twenty-seven miles by road from Cobar; on Meryula Pastoral Holding; about 8 miles east of homestead, and 14 from Meryula railway siding; parish Rochford, county Robinson.

Inspector Polkinghorne reported (P.B. $\frac{A}{0}\frac{1}{7}\frac{1}{1}$) a large outcrop of ironstone in slate, which at the 100-feet level in the shaft shows some very nice gossan. Aided to sink from 100 to 300 feet level.

At a later date the local Warden's bailiff reported traces of copper.

Nyngan Division.

Great Western Mine.—Portion 189 (?), A. Leslie's settlement lease; parish Wilgabone, county Canbelego.

Copper carbonate in schist. Surface indications first observed by J. McMillan about 1887. About 1901 a shaft was sunk to 75 feet.

In 1906 a Cobar syndicate re-opened it under the above name. A little ore at grass in 1907 was of a very siliceous nature, being much mixed with quartz.

Average value, about 5 to 7 per cent. At 75 feet in the old shaft it is reported that the ore dipped away, none being visible in the shaft at that level.

The new proprietors, for some fanciful reason, started a new shaft some 150 feet away to N. 20° E., where there was not the slightest indication, and, instead of following whatever lodestuff there is in the site, proposed to sink 300 feet in blank country and then crosscut to the old shaft. From the indications in the latter the prospects are poor enough, without the dead work in view.

Ten tons of ore from this mine are reported to have yielded a net return of £17 at Lithgow.

Work suspended at end of 1907.

Canbelego Division.

Hermidale District.—The Budgery Copper lode, so far as proving at a considerable expenditure goes, consists of an isolated impregnation, like those of Great Cobar, Nymagee, Mount Hope, &c. Around the boundaries of the Budgery leases prospecting shafts have been sunk to considerable depths, with extensive crosscutting, but all failed to raise even a colour of copper ore. Many of these ventures, unfortunately, were floated on the strength of the one discovery, and the shares boomed and inflated on the market—most unjustifiably, for never at any stage were there any prospects in the majority of them. The following were floated round the Budgery:—

Budgery Reward Mine.
Budgery Reward North.
Budgery Reward South.
Budgery Wattle.
Budgery North Blocks.
North Budgery.
South Budgery.
South Budgery Extended, and others.
Budgeryrogan.
Budgery King.

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Cobar Mining District—*continued.*

Nyngan Division.

Hunter's Claim.—Four miles north-west of Girilambone. Described by Inspector D. Milne as a strong body of ironstone, with occasional splashes of copper carbonate.

Originally aid granted to Hartman and party to sink from 138 to 150 feet, and crosscut 150 feet. Specimens from 226 feet assayed 8 per cent. of copper. At 240 feet a drive was put in west.

Inspector J. R. Godfrey reported (P.B. $\frac{8}{3}\frac{4}{0}\frac{1}{0}\frac{8}{.}$) that the shaft was 137 feet deep on hanging wall; a crosscut driven west from this level, and from it a winze sunk 103 feet = 240 feet. Lode became more mineralised with depth. No further work recorded.

Judging from the material at surface, pyrites became prominent, but copper value very low.

Bobadah Division.

Long Panel Lode.—Three and a half miles east of Yellow Mountain, in parish Bluff, county Flinders. Outcrop traced for 152 feet, width 9 feet. Discovered by P. Fineren and T. Hart, July, 1908. Carbonates from outcrop assayed 11·8 per cent. copper.

Gilgunnia Division.

May Day Mine.—In this mine a considerable amount of prospecting has been done for gold, but, like the rest of the field, with little success, the gold being disseminated through slate near the junction of porphyry, but not in sufficiently concentrated form to pay for working. Lead carbonate occurs freely in small veins and vugs, and is usually rich in silver. The metalliferous belt at the May Day is upwards of 100 feet in width. It strikes about north-east, with a south-easterly underlay. At 85 feet in the north-east shaft copper carbonate and red oxide made their appearance, and continued to 102 feet. These ores occur in a width of about 3 feet, and at 102 feet dipped out of the shaft. The ore is of good quality, but further testing is necessary to determine quantity. A sample of carbonate of copper and carbonate of lead, assayed $\frac{8}{0}\frac{8}{0}\frac{4}{0}\frac{0}{0}$, yielded copper 7·84 per cent., lead 5·94 per cent., and silver 16 oz. 19 dwt. 17 grs. per ton.

Nyngan Division.

Moondyke Copper Mine.—Nine miles south of Girilambone Railway Station, parish Gidalambone, county Canbelego, 5 miles from railway line.

Inspector R. Schloesser reported (P.B. $\frac{2}{0}\frac{6}{1}\frac{4}{4}$) carbonates and specks of grey ore in chlorite and talc schist.

Aided to sink from 23 feet to 53 feet, and to crosscut 20 feet at bottom.

At 40 feet carbonates in shaly rock assayed 8 per cent. copper.

Inspector J. Polkinghorne reported (P.B. $\frac{3}{0}\frac{8}{0}\frac{8}{0}\frac{8}{0}$), that the previous party sank 43 feet. A new party crosscut west 25 feet, and exposed lode 6 feet wide; then continued shaft to 55 feet; copper showing at that depth.

Further aided to continue to 100 feet. At 85 feet drove north-west. About 5 tons of fair ore on surface, obtained within 30 feet of surface. No further record.

Canbelego Division.

Mount Boppy Copper Mine (formerly New Burra Burra).—Portions 50 and 51, parish Buppe, county Mouramba, 6 miles southerly from Boppy Mount Railway Station, and 4 from Canbelego. Discovered by W. Frost.

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COBAR MINING DISTRICT—*continued.*

Strike N.W. in slate and sandstone close to junction of porphyry. Dip slight to N.E. Lodestuff—slate, quartzite, and gossan. Ores—carbonates, black oxide, and yellow sulphide.

Length of proving (in October, 1907) about 150 feet, depth 200 feet. Gross output in recent campaign about 500 tons. 380 tons disposed of during 1907 for £1,800.

History.—First lease taken up in 1886. At 13 feet carbonates and grey ore were struck in the lode, which had a thickness of 5 feet. 30 tons of picked ore assayed 38½ per cent. of copper.

In 1887 little work was done, the lease being sold to a Cobar syndicate.

In 1888 mining was suspended, owing to scarcity of water; a tank, however, was being excavated, and a small reverberatory furnace erected.

In 1889 a quantity of ore was reduced to matte, but the quantity was not stated.

In 1890 500 tons of ore were raised, and about 6 tons of copper produced.

In 1891 stoping and smelting ceased, and Government aid was granted to further explore the lode.

In 1893 the mine was closed.

In 1897 Inspector D. Milne reported that the lode was being prospected; the main shaft had reached the 200-feet level, from which a crosscut 70 feet west exposed bunches of sulphides.

In 1898 compulsory sale of surface gear put an end to operations.

Further aid was granted for sinking in 1901 (P.B. $\frac{a\,2\,p\,a}{0\,1}$), and again in 1902 (P.B. $\frac{a\,0\,2\,a}{0\,2}$) for testing the east split of lode from 20 to 70 feet, and to crosscut 50 feet; resulting in discovery of a width of 15 feet of carbonate veins and strings of low grade. Aid granted to drive along this line for 50 feet.

Re-opened about 1904. Company formed to work it in November, 1906.

Position in October, 1907:—Principal workings in M.L. 10. Two lodes—east and west—60 feet apart, striking N. 60° W. East lode vertical; west lode dips 12° to 15° to 90 feet, thence vertical. East lode, shaft and winze sunk 259 feet; west lode, 200 feet. Length of proving—east lode, 100 feet; west lode, 120 feet. Levels driven at 90 and 200 feet in both shafts; and crosscuts connecting both lodes at these levels.

The sulphide zone of the *east lode* has been opened for about 100 feet. Lode about 3 feet wide; ore occurs in lenses of pure quality; rest of formation, dredgy quartz and slate. Very little iron pyrites present. Winze 59 feet below 200-feet level, filled with water; ore in it reported to be of good quality; a little still visible in roof above winze.

Channel narrow at north end of level, evidently a blank. To south, channel filled with dredgy material; should be driven on.

The *west lode* has been intersected by crosscut from the north end of 200-feet level in east lode. From this point north-westerly good ore was followed for some distance up to 10 feet in width. At 60 feet from the crosscut, however, it is narrow, but widens underfoot.

To the south-east, beyond crosscut, the lens thins to about 1 foot of rich ore, and to a mere thread at 50 feet. A little ore is, however, showing on east wall. Channel being defined, should be driven on.

A crosscut was driven N. 30° E. for 50 feet to the porphyry contact, which revealed no ore.

Water making freely above 200-feet level; winze below was dry, but filled from upper levels.

The ore raised from the large lens in west lode is of good grade. At surface it is broken, and hand-picked for "firsts." Fines from mining and spalling

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is screened. The screened ore is then concentrated in four small handjigs. These two classes are despatched for sale at Customs Smelting Works.

The "seconds" from hand-picking floors are stacked, probably aggregating several hundred tons.

The following assays of carefully selected average samples of the different classes reveal their quality :—

No. of Assay.	Class of Ore.	Copper.	Iron.	Sulphur.	Silica.	Gold per ton.	Silver per ton.
		per cent.	per cent.	per cent.	per cent.	trace	dwt. grs.
07-7488	Average of "firsts"	18·95	....	....	....	,,	8 17
07-7489	,, "seconds" (stacked)	1·50	....	....	....	,,	trace
07-7487	,, "fines" from screens	8·55	14·42	7·94	49·00	,,	5 10
07-7434	,, "concentrates" from jigs.	16·22	21·42	16·07	28·70	,,	7 15
07-7436	,, "fines" from hutches	7·72	13·23	6·72	46·15	,,	5 10
07-7435	,, refuse from jigs.....	2·70	10·08	2·74	59·25	,,	3 6

Close to the main Mount Boppy copper workings a shaft has been sunk in the north block in soft, rotten slate without sign of ore. Southwards the lode outcrops through M.Ls. 50 and 51, and Mount Boppy South. In places gossany iron and ferruginous slate are prominent in the outcrop. Two shafts were sunk to 100 feet and 180 feet in M.L. 51. In the latter at 12 feet west in a crosscut about 20 feet of impregnated rock is reported to yield an average of about 2 per cent. of copper. A little carbonate and sulphide ore have been raised from it. A greenish pyritic slate on west wall doubtless accounts for the very ferruginous slate at surface.

In the South Mount Boppy shaft adjoining, a 50 feet shaft on the west side reveals decidedly encouraging prospects, 3 to 4 per cent. carbonates being raised in some quantity, which could be picked to higher grade.

From the data secured it appears that the Mount Boppy copper lode is formed of a series of lenses with blanks between. It is worthy of attention; but capital is necessary for proper development, both vertically and horizontally, before establishment of local smelting works.

The latest report, dated 12th March, 1908, records the depth of the winze as 70 feet below the 200-feet level. Driven 6 feet at bottom in solid yellow ore for full width of drive.

The first payment under an option was made about the same date.

During 1907, 380 tons of ore were disposed of for £1,800. (Ann. Rept. 1907, p. 51.)

Mount Hope Division.

Mount Hope Copper Mine (previously New Mount Hope).—Discovered by a miner named McDowell about 1878. In 1880 it was visited by Mr. L. H. G. Young, accompanied by the Writer. A shaft had been sunk, but the mine was practically abandoned at that date. Mr. Young reported ($\frac{1880}{p.\ 2\ 6\ 0\ 1}$):—"The copper mines at Mount Hope may be divided into three outcrops, more or less in a line with each other, namely, Mount Hope, South Mount Hope, and McDowell's. Of these, Mount Hope is in iron sandstones, having a strike N. 7° E. and dipping 80° to the west, while the other two are in a porphyry formation. The copper at Mount Hope appears to occur in a defined lode, composed largely of quartz, argillaceous matter, and earthy blue and green carbonates of copper, with occasional masses of red and brown iron ore, and also some earthy red oxide of copper and grey sulphide. The main lode is 24 feet wide on the surface, and there are two parallel outcrops. The whole may, however, be looked upon as what is known to miners as a "blow," and affords no idea of what the width of the lode will be lower down. The lode has a strike N. 7° 30′ E.

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Mount Hope Copper Mine.

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"A shaft has been sunk to a depth of 60 feet on the main outcrop, and some earthy carbonates extracted and dressed. There being no means of descending the shaft, I was unable to ascertain the appearance of the lode at the bottom of it.

"Like most of the copper deposits in this district, the Mount Hope lode crops out on the top of a small hill."

Mr. Young stated the most probable cause of the elevation was mineralisation of the country enclosing the lode during process of mineral deposition.

The Mount Hope outcrop presents features common to both the Cobar and Nymagee lodes, viz., ferruginous slates and sandstones seamed with quartz veinlets, striking about N. 10° E. Mount Hope consists of a long low ridge. The median line, or backbone, consists of a thick bed of sandstone, quartzitic in character, and is flanked east and west by ferruginous slates and alternating bands of sandstone. The quartz veins which seam the rock occur horizontally as well as vertically. Silicification, oxidation, and cementation of iron salts have greatly indurated the strata, destroying the fissility of the slates, and converting the sandstones partly into quartzites. The matrix of the lode as a rule is exceedingly hard, particularly in the sulphide zone, where the ore consists of an impregnated fine-grained sandstone. This induration increases the cost of winning considerably. The ore bodies are not defined within "walls" (which are conspicuous by their absence); in other words, they consist of segregations or replacements in the country itself without definite boundaries.

As at Cobar and Nymagee, some of the surface ores were extracted by open cut at the one place where ores appeared in the outcrop. Below ground the longest longitudinal extension of ore measured about 400 feet, but was solid only for about 150 feet, the principal portion of this deposit having a width of from 60 to 80 feet. Beyond the furthest extension of this body of lodestuff ore has not yet been found, but practically no prospecting has been done beyond 100 feet north and south of the workings. It is regrettable that during the prosperous days of the mine no attempt was made to test the considerable extent of ground lying north and south, which presents favourable indications of mineralisation, though no copper ore appears at surface. Considering the large blanks in the Great Cobar Mine between the main ore bodies, it is possible that similar ones may occur at Mount Hope; at all events, a trial is justified. The occurrence of ore bodies as isolated masses in the country renders it possible to miss them—as happened in the early workings—between ordinary levels and crosscuts.

The oxidised ores consisted chiefly of earthy carbonates, with thin veins of red oxide and grey sulphide. As these ores were raised at date of inspection in 1898, the first grade went from the breaker to the charging bins; the seconds passed from the breaker to Cornish rolls, and thence to Cornish jigs. As raised, the ore averaged from 4 to 5 per cent.; by dressing and jigging it was brought up to 14 or 15 per cent.

Sulphide ore only is now being mined. Unfortunately, the fine sandstone matrix is extremely hard, and, still worse, iron sulphides are almost absent. The change to sulphides began about the 160-feet level, and passed completely into them at 270 feet. The sulphides, owing to the absence of iron pyrites, are high grade when clean, but are leanly distributed through the matrix.

The concentrating plant consisted at the time of six Cornish jigs, which performed very clean work when the ore was crushed to a finer mesh than

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formerly, but their capacity was very limited, and considerable time was lost in discharging the hutches twice a week. The absence of a flow of water prevented the hutchings (fines) from being as free from sludgy slime as would be possible with a continuous flow and discharge. About 1 ton of ore in 5 was obtained by this method of treatment.

The seconds consisted chiefly of light carbonates, having a reported assay value of from 5 to 6 per cent. of copper, though the later seconds of finer crushings appeared to fall below this estimate. Owing to the earthy nature of the carbonates in the large heaps of seconds from the early workings (7,000 to 8,000 tons, estimated), mechanical separation from the waste did not appear possible; a cheap leaching process alone would be effective.

The smelting-plant formerly consisted of five furnaces, but two only were then in use. Fire-bricks are made from a sandy clay obtained at a depth of 60 feet, at a distance of 7 miles from the mine. Its composition may be studied in the section devoted to fireclays and bricks, where an analysis appears. It was first discovered in sinking a well for water. Most durable bricks were made from it direct after crushing, being burned in one of the old reverberatory furnaces. The Great Central and Crowl Creek Mines also drew their supplies from this source.

The furnace charge contained about 23 cwt. of ore, a larger charge not being possible owing to its composition. It was made up as follows in barrow-loads, which run about six to the ton in ore and flux:—

4 barrows hutchwork (carb. and oxide fines).
2 ,, raggings (carb. and oxide fines).
1 barrow sulphides (hand-picked).
1 to 2 barrows picked slag (with prills).
1 barrow ironstone flux.
2 barrows charcoal.

Sometimes one of ashes was added. Four charges were reduced in twenty-four hours. Since adding sulphides, a cleaner slag resulted than formerly.

The ironstone flux was carted from Mount Allen, a distance of 10 miles, and formed a serious item in the expenditure. A large amount of this flux was used by the New Mount Hope Company before its auriferous nature was discovered, which resulted in the Mount Allen Gold-mining Company being formed. Gold-mining operations were established and successfully maintained for a time, until the yield fell below payable proportions. Cyanidation was afterwards resorted to for the large amount of ironstone tailings produced by battery treatment. The tailings were purchased by the copper company at 7s. per ton for fluxing purposes, but the supply was stopped in view of the new treatment. The purchase, mining, and carriage of ironstone flux at the Mount Hope entailed an expenditure of 15s. per ton, which should expedite the development of the sulphide resources of Mount Hope. Firewood cost 6s. 6d. per ton, and charcoal 37s. 6d.

At the end of March, 1902, the mine was closed on account of copper falling below a figure which was remunerative to the company.

It was decided to meet the lower market by re-equipping the mine with modern appliances, but shareholders failed to respond with necessary capital. The company was then wound up and later on the mine was sold by auction.

Mr. R. N. Kirk, Manager of the New Mount Hope Company, stated that the total output of the mine, from the commencement of operations on the

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Mount Hope Copper Smelting Works.

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COBAR MINING DISTRICT—*continued.*

30th April, 1881, to 31st December, 1898, amounted to 5,070 tons 0 cwt. 3 qrs. 8 lb. of refined copper. After four years' idleness the mine was reopened in February, 1906, under a new proprietary.

RETURN of the yearly outputs and progress of the New Mount Hope Copper Mine, compiled from the Annual Reports of the Department of Mines.

Year.	Ore smelted.	Copper product.	Value.	Deepest shaft.	Deepest level.	Width of lode.	Number of furnaces.	Value of plant.	Men employed.	Remarks.
	tons.	tons.		ft.	ft.	ft.		£		
1883	2,088	431·0	..	268	150	(?)	Four Reverberatories.	7,612	200	Operations started by the New Mount Hope Copper Co. in April, 1881, but no returns are available for that and the following year.
1884	6,194	1258·0	..	340	270	10 to 50	....	..	236	
1885	3,795	635·0	..	..	..	..	....	..	..	Work suspended owing to low price of copper.
1886	..	..	..	..	..	..	....	..	..	A few hands employed at developmental work.
1887	..	..	..	..	..	..	....	..	..	Steps being taken to re-open mine.
1888	1,187	137·0	..	..	..	..	....	..	..	Ore to the value of £4,800 raised; 1,187 tons smelted.
1889	1,870	260·0	..	..	..	..	....	..	..	
1890	1,143	218·0	..	340	340	68	....	700	46	Worked on tribute.
1891	1,094	208·2	..	340	340	58	....	700	36	,, ,,
1892	(?)	190·0	..	340	340	..	....	..	40	,, ,,
1893	(?)	(?)	..	340	340	..	....	..	40	,, ,,
1894	892	135·0	..	340	340	..	....	..	36	,, ,,
1895	858	143·5	..	340	340	58	....	..	38	,, ,,
1896	1,092	141·5	..	340	340	..	....	..	36	,, ,,
1897	734	97·3	..	340	340	..	....	..	40	,, ,,
1898	992	131·6	..	360	..	..	....	..	..	,, ,,
1899	662	103·7	..	..	..	..	....	..	..	Worked under tribute until July, 1900—then by the company.
1900	1,560	242·3	..	..	..	..	....	..	..	Produced from 2,212 tons of mine ore and 2,775 tons of tailings, concentrated to 1,560 tons of smelting ore.
1901	3,451	177·2	..	..	..	..	....	..	..	In 1900 the company installed new concentrating and other machinery.
To Mar. 1902	..	47·1	..	..	..	..	....	..	..	
1906	6,960	173	..	..	..	..	....	..	..	Re-opened in February, 1906.
1907	8,500	806	..	..	..	..	....	..	67	Worked continuously in 1907. Handcock jig added to concentrating plant.

Mount Hope District.—At Mount Allen some years since a tunnel on the north-west side was driven some distance in search of copper, but nothing of importance was discovered.

At Coan Peak, on the south-west side, a little copper has been discovered in porphyry. Three shafts were sunk to shallow depths, following a quartz vein. The occurrence is known locally as the Coan Copper Mine, Mineral Lease 33, parish Coan, county Blaxland, but no workable or defined ore body has been found.

Double Peak—locally known as "Dromedary"—consists of porphyry and slate. On the west side, opposite the village of Mount Allen, a rather extensive outcrop of magnetic iron occurs, in parts highly silicious. Stains of copper carbonates are visible in solid pieces of the magnetite. A considerable quantity of the latter was carted to Mount Hope for fluxing purposes. This site was originally opened for gold. In a shaft sunk 50 feet alongside the ironstone, pyrites was met, and in an eastern crosscut copper carbonates; but the latter was not followed, as gold was sought at

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the time. On the top of the east peak, copper carbonates cropped out in a claim held by McGuire and party in 1898. A little further south, on the same line, gold was found in ironstone and ferruginous slate, from which various parcels yielded from 4 dwt. to 17 dwt. of gold per ton. The lodestuff closely resembles that of Mount Allen Gold Mine. Aid was granted to Hill and party to tunnel into the mountain at a level about 200 feet below the auriferous outcrop on the slope. At 340 feet the lodestuff was cut, consisting of soft slate with iron and copper pyrites, the latter, however, not in payable quantity.

Seven miles due north of Mount Hope, parish Mount Allen, county Blaxland, on Mount Allen Mountain, 6 miles south of Double Peak; 2½ miles west of main road to Mount Hope.

Inspector R. Schloesser reported (P.B. $\frac{44}{0\frac{1}{2}2}$):—Porphyry, with slate and sandstone. Bodies of gossan carrying copper ores extending into the porphyry. A shaft, previously sunk by a Mount Hope syndicate, had disclosed several small pockets of good grey ore. Aided to extend tunnel to 143 feet. Tunnel driven across chloritic slates, a few stains of copper in face at 145 feet. 25 feet further driving granted. Aid also granted to sink 40-feet shaft a further 25 feet. Copper stains showing in full width of shaft. No payable deposit disclosed in these operations.

Inspector Polkinghorne reported (P.B. $\frac{11}{0\frac{1}{8}1}$) veins of copper ore 22 miles north of Mount Hope, in parish Killen, county Blaxland.

(MUDGEE MINING DISTRICT.—*Dandaloo Division.**)

Mount Pleasant Copper Mine.—Albert Water Holes, M.L. 4, parish Alberts, county Kennedy. Thirteen miles from Bogan River at Dandaloo: 40 from Trangie Railway Station, and about seven from surveyed Bogan Gate–Bulbodney Railway line.

Discovered by C. J. Keenan, about April, 1898.

Strike N. 20° E., dip westerly 13 feet in 100 feet. Width, 4 to 5 feet; length of proving, 116 feet; depth, 100 feet. No visible outcrop of east lode. Very slight in main lode.

Two parallel lodes occur about 10 feet apart; workings on *west* or main lode. *East lode* reached by crosscut at 100-feet level. Width about 1 ft. 3 in. to 3 feet. Driven on 70 feet. Footwall well defined, polished and coated with flucan; evidencing permanence. Dip slightly east.

Between the lodes contorted schist occurs, with occasional copper stains and quartz.

The ores worked in the main lode occur as bunches and pockets, mostly grey ore and bornite; yellow sulphide zone not yet reached. General character of lodestuff silicious, but capable of dressing up to high grade. Ore lens pitches southerly. Driven on 70 feet at 100-feet level, and stoped up 15 feet, and for a total length of 110 feet, including higher levels. Pinched at north end, but will probably open on strike.

COBAR MINING DISTRICT.

Nymagee Division.

Nangeribone, p. 280.

North Nymagee Copper Mine, portions 4, 5, and 23, freehold, parish Priory Plains, county Mouramba.—Taken up adjoining the Nymagee Mine

*Should appear on page 294.

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in 1880, and originally known as the Hartwood Mine. The south boundary of this property is but a short distance from the most northern open workings of the Nymagee Mine, but notwithstanding a large amount of work, no defined payable ore body has yet been discovered. At the boundary two shafts have been sunk, 200 and 293 feet respectively, and connected by a crosscut at the 200-feet level; the connecting level intersects the strike of the Nymagee lode. At 30 feet west of the 200-feet shaft (No. 1), a channel, 13 feet wide, was cut in the crosscut. The filling consisted of broken country, with zinc-blende and a little galena, and very rarely copper pyrites. Southerly, a short distance in the Nymagee Company's property, is an outcrop of ferruginous carbonate of lead, which apparently corresponds with the strike of the main lode.

Four hundred feet north from No. 1 shaft, No. 3 has been sunk 112 feet. A little copper ore was found near surface, but none is showing in the shaft. The best deposit on this property was located 720 feet N. 55° W. of No. 1 shaft; here a bunch of good ore was stoped out some years ago and sold to the Nymagee Company. The chute of ore was stoped 30 feet long from the 70 to the 130-feet level. The main shaft is 400 feet deep in a mineralised belt about 15-feet wide, carrying a little copper sulphide which might possibly be concentrated. Some better class ore has been obtained in a drive along the ore channel southerly.

Inspector J. R. Godfrey reported deepest shaft in 1900 as 300 feet. Ore raised in 1900, 700 tons. No extensive ore bodies found. Small lenticular patches of rich ore occasionally met. Ore contains copper, lead, zinc, and silver.

Later developments: In No. 1 shaft, lode 4 to 5 feet wide at 300-feet level; dip west at 15°.

No. 2 shaft, 400 feet: lode, 10 feet wide at 200-feet level; dip east at 15°; length proved, 200 feet; gross output, 2,000 tons.

An option was obtained in 1907 by the present holders of the Nymagee Mine, but was not exercised.

Nymagee Copper Mine, portions 1, 2, 11, 22, 23, parish Priory Plains, county Mouramba.—This mine was opened in 1880, having been floated into a company by Mr. Russell Barton. The earliest geological description dates from within three months of the beginning of mining operations, when Mr. L. H. G. Young, accompanied by the Writer, visited the locality, and reported as follows, $\frac{1}{D}\frac{8}{2}\frac{8}{6}\frac{0}{1}$:—"The slate rocks adjoining the copper deposits are of a sandy character, and have a strike of N. 24° W., dipping to the south-west at an angle of 68°. At Nymagee Mine there appears to be two lodes. The main lode has a strike of N. 17° 30′ W., and is nearly vertical; three shafts have been sunk upon it, at a distance of 276 feet apart. To the east of the middle shaft (No. 3) may be seen the outcrop of a branch lode, having a strike of N. 9° E., and which as yet remains unexplored. In the three shafts sunk at that date to (1) 120, (2) 55, and (3) 80 feet, respectively, the width and composition of the lode at these levels were—(1) 8 feet wide, composed almost entirely of yellow sulphide mixed with black oxide of copper; at (3) 55 feet, the lode is 8½ feet wide, and is composed of earthy carbonates, grey sulphides,

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and red oxide of copper, mixed with decomposed slate and brown iron ore; at (2) the lode is 5½ feet wide as yet, but the whole width has not been exposed; it contains large masses of brown iron ore, and grey sulphide, and red oxide of copper.

"The second lode on this property is called the 'East Lode.' It has a strike N. 18° W., and is composed of argillaceous matter, earthy carbonates, red oxides, and grey and yellow sulphides of copper, the latter only in patches.'

In November, 1898, the Writer visited the mine, but, unfortunately, owing to failure of the water supply—the first time for a number of years—mining operations had practically ceased, and it was not possible to inspect below the 40-fathom level. Nymagee, like Cobar, has to contend with an arid climate and waterless surroundings. During a severe drought in 1882–3, copper to the extent of over 1,300 tons accumulated at the mine, owing to impossibility of transport. The remarks under the head of Great Cobar, touching initial difficulties, apply equally to Nymagee, Great Central, and Mount Hope Mines. The lode at the lowest level is reported to be 30 feet wide, and composed of massive pyrites, containing about 2 per cent. of copper, though a couple of narrow seams of good grade occur. In 1896 the mine was purchased by the Great Cobar Mining Syndicate, who substituted a blast-furnace for reducing, and subsequently established partial pyritic smelting in 1901, heap roasting being discarded. The reverberatory furnaces were retained, however, for matte roasting, the latter being brought up to high grade before despatching to the syndicate's refinery at Lithgow, the distance to the nearest railway station (Hermidale) being 45 miles.

The syndicate did not work below the 600-feet level, operations being largely confined to robbing the old stopes of left and discarded ores.

Fireclay is obtained about 3 miles from the mine, and is mixed with crushed quartz in the manufacture of firebricks. Its composition may be seen under the head of "Fireclays."

The quality of Nymagee copper has always been remarkably pure and free from injurious associates. An assay of the refined copper returned 99·74 per cent., and silver at the rate of 3 dwt. per ton, but no gold.

The main sulphide ore body averaged about 250 feet in length by about 15 to 20 feet in width, and yielded on an average about 10 per cent. of copper.

Several parallel smaller veins have been opened in crosscuts east from the main workings.

The carbonate ores were extracted largely by open cut.

The Nymagee outcrop closely resembles that of Cobar, save that the slates and sandstones stand up more conspicuously above the ordinary surface; they strike N. 30° W. The outcrop of copper ore was comparatively small and confined to one spot, which has since been exploited by open cut. In only two places was iron oxide noticeable on the surface. One of these, at the south-east end, has not yet been extensively prospected. Copper carbonates stain many of the joint and cleavage planes of the strata to the eastward of the main outcrop, but no defined lodes have been exposed.

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Cobar Mining District—*continued.*

The extent of the output, and the progress of development, is shown in the following table of returns:—

Return of the Yearly Output and Progress of the Nymagee Copper Mine; compiled from the Half-yearly Reports of the Nymagee Copper-mining Company, Limited, the Annual Reports of the Department of Mines, and from returns supplied by the Great Cobar Mining Syndicate.

Year.	Ore smelted.	Copper produced.	Per-centage.	Deepest level.	Width of ore bodies.	Remarks.
	tons.	tons.		ft.	ft. ft.	
1881.....	6,053	359	13·61	240	15 to 25	Output since starting in 1880.
1882.....	6,618	1,144	17·13	240	2 ,, 30	
1883.....	10,236	1,714	16·75	310	3 ,, 18	
1884.....	14,743	2,207	14·95	310	4 ,, 12	
1885.....	15,773	1,791	11·35	430	4 ,, 12	52,000 tons of wood consumed annually.
1886.....	14,449	1,468	10·15	516	4 ,, 12	
1887.....	10,739	1,036	9·64	618	10 ,, 25	
1888.....	12,826	1,297	10·11	618	8 ,, 20	Copper boom year.
1889.....	8,704	836	96·6	720	8 ,, 20	Collapse of boom.
1890.....	8,098	792	9·78	720	8 ,, 20	
1891.....	9,537	916	9·60	720	8 ,, 20	
1892*	6,238	697	11·01	720	8 ,, 20	
1893.....	.....	.....	....	....	.....	Mine closed owing to low price of copper.
1894*	1,688	148	8·76	720	.....	
1895*	6,845	485	8·29	720	.....	Mine worked on tribute.
1896*	3,249	380	11·08	720	.....	Purchased by Great Cobar Syndicate.
1897*	11,910	510	4·23	....	.....	
1898.....	17,153	695	4·01	....	.....	
1899.....	14,868	501	3·36	....	.....	
1900.....	16,183	533	3·30	....	.....	Returns supplied by Dr. R. Read, Managing Director, Great Cobar Syndicate.
1901.....	15,521	518	3·33	....	.....	
1902.....	18,636	649	3·48	....	.....	
1903.....	22,036	577	2·61	....	.....	
1904.....	24,159	700	2·89	....	.....	
1905.....	24,251	596	2·45	....	.....	
1906.....	26,649	666	2·49	....	.....	Ann. Rept. Dept. of Mines.
1907.....	14,079	306	2·17	....	.....	,, ,, ,,
Total	341,191	22,021				

* Amounts smelted not specifically stated, but for statistical purposes are assumed to correspond with amounts raised.

Mine purchased by the Nymagee Copper, Limited, in December, 1906. Deepest shaft and level, 680 feet. Large bodies of 3½ per cent. ore opened in No. 6 level south; width, 30 feet. Extensive alterations and additions to plant effected in 1907.

Quartz used for flux; less will be required when new makes of ore at 600-feet level becomes available.

Water Jacket equal to about 220 tons per 24 hours, exclusive of silica flux; 5 per cent. Bulli coke used.

In the early part of 1907, the new company decided to pull out all the old plant, with the exception of the blast furnace, and to instal modern machinery. The dismantling operations involved the suspension of productive work for six months, and entailed an expenditure of some £18,000. The output for the year was, therefore, only 306 tons of copper as against 666 tons for the year 1906.

"The following details of the new plant installed were supplied by the company:—Two Babcock and Wilcox high-pressure boilers of 500 horse-power, with new brick stack for same; a direct high-pressure winding engine, capable of sinking to 2,000 feet and of raising a load of 8,000 lb., with a steam pressure of 125 lb.; a compound steam and air compressor of a capacity of twenty drills; a high-pressure blower, compound engine, capacity 110 cubic feet per revolution, with a pressure of 48 oz. The fitting shop

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has been equipped with new lathes, boring and punching machines, and every thing necessary to make it complete. New buildings have been erected over the winding engine, compressor, boilers, blowers, and fitting shop. Poppet heads, about 60 feet high, have also been erected.

"The mine was further opened up, and, by leaving the old drives, large lenses of ore were located which had been previously missed. At the No. 1 level (lowest) one chute has been opened out for a length of about 200 feet, of an average value of over 3 per cent., and for a width of about 15 feet; and judging by appearances at date, there may be still more ore on the eastern side. Another chute is 175 feet long, and the indications point to it continuing further north. As this level is further opened up, the management think the large chute will be located, and what applies to this level may also apply to the upper ones.

"At the smelting furnace no improvement has been made in the size. All that was done was to erect some ore bins, as it has been shown that it would be practically impossible to get in a supply of coke and firewood sufficient to meet the requirements of large treatment works under the present conditions of hauling some 45 miles by teams from the railway. It was also considered advisable to make a test with the present furnace as to the quality of the ore and its smelting qualities, and 8,216 tons were smelted for 213½ tons refined copper. This proved that it is a suitable smelting mixture, and that there is no necessity to go outside the mine for fluxes.

"Unfortunately, with the low price of copper and the high rate of cartage, it was found impossible to make a profit with the present grade of ore, unless a much greater tonnage could be smelted. This was, however, impracticable under the present conditions of road cartage; so the mine has been closed down pending consideration of some method to facilitate transport to and from the mine. The shutting down of this mine means a loss of some £60,000 per annum to the State." (Ann. Rept., 1907, p. 50)

Nymagee, 3½ miles south-south-east, on the Hartwood Pastoral Holding, parish Roset, county Mouramba.—Inspector J. Polkinghorne reported (P.B. $\frac{1\,4\,9\,0}{0\,7}$): Quartz, gossan, and slate, about 3 feet wide, in porphyry, carrying small values of gold, silver, and copper.

Cobar Division.

Occidental Gold Mine, Cobar.—Two lodes occur—"Big Lode" and "West," or "Gossan Lode," about 3 feet to 20 feet apart. Big Lode about 70 feet wide, West Lode 15 feet. The Big Lode pinches at both ends, and splits into strings. West Lode traceable to Mount Pleasant Mine on N. 15° W. strike. Worked for gold down to nearly 340 feet. Milling ore difficult below about 250 feet. Sulphides begin about 340 feet. Shaft sunk in country on west side down 540 feet in October, 1907. Water makes at 440 feet; averages about 20,000 gallons per day; practically none in bottom of shaft. Greatest length of Big Lode worked, about 560 feet; greatest length of West Lode proved in No. 1 level, 830 feet; greatest length worked in stopes, about 150 feet.

The East lode, Great Western Section, about 120 feet east of the Big Lode, evidently dies out before reaching Occidental lease, as it was not met in crosscut. Traces of carbonates of copper only in the oxidized zone of Occidental Lode, just above water-level. No. 5 crosscut at 540 feet, shows still less, probably not averaging more than 1 per cent.

Queen Bee Copper Mine.—M.Le. 33 and 34, parish Narri, county Robinson, about 13 miles south-east of Cobar. Country, slate and sandstone. Strike

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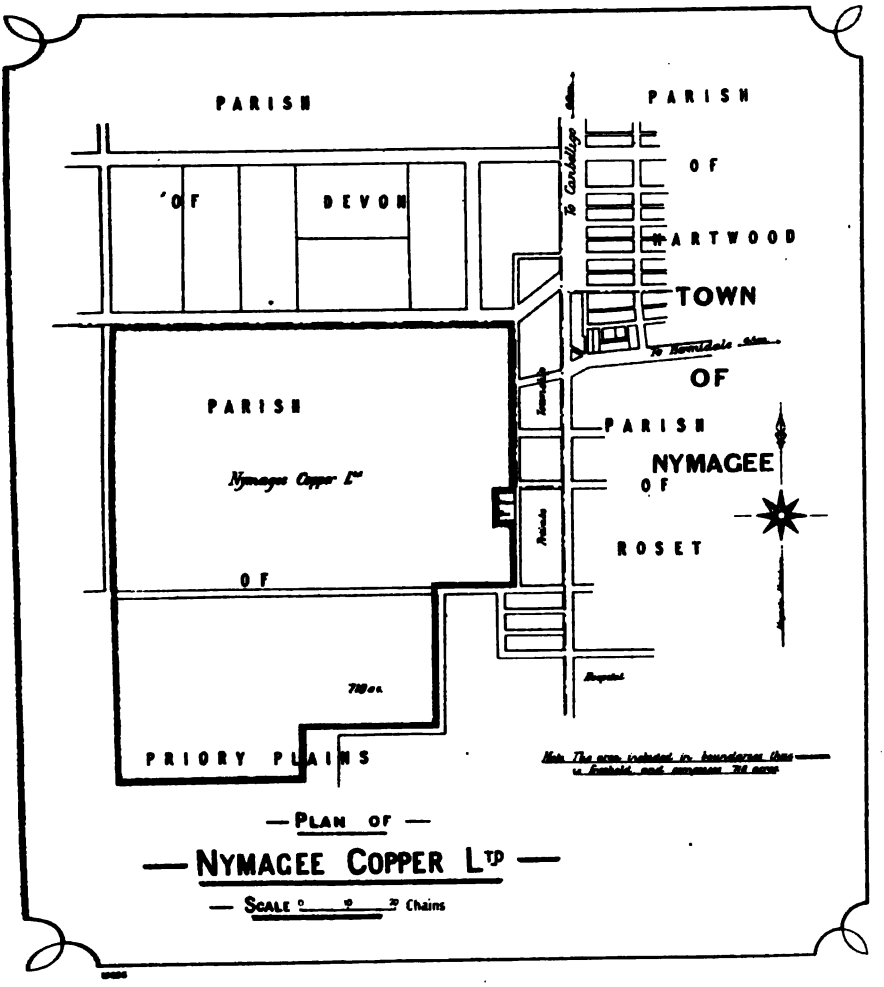
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N. 40° W.; dip, S. 50° W. at 1 in 12. Prospected for gold prior to discovery of copper. Taken up again early in 1902. Aided from Prospecting Vote. Rich grey sulphide struck in June, 1902, at 85 feet, and followed down to 150 feet. Drives started on rich ore at this level. First ore despatched in September. First copper produced at mine, June, 1904.

Progress of development.—The Queen Bee Copper-mining Company, No Liability, began operations 15th December, 1903. The following notes are extracted from the half-yearly reports:—

First half-year, ending 30th June, 1904.—Greatest depth of proving, 250 feet; length, 300 feet. Reverberatory furnace begun in March; smelting in May. No. 2 furnace in course of erection. Tank, 2,000 yards, excavated.

Second half-year, ending 31st December, 1904.—No. 2 furnace completed in September; No. 3 in December. Main shaft, 336 feet Greatest length of proving, 400 feet; widest part of stopes, 25 feet. Weigh-bridge, rock-breakers, picking-table, hoppers, ore-bins, saw-bench, workshops, brickmaking plant, &c., installed.

Third half-year, ending 30th June, 1905.—Main shaft, 370 feet. No. 3 furnace started in March. Tramway constructed over furnaces for feeding through hoppers. Tank increased to 3,000 square yards. Fire-bricks made at mine.

Fourth half-year, ending 31st December, 1905.—Pumping appliances installed in main shaft, now 425 feet; Babcock boiler set up. No. 4 furnace completed in December. Tank increased to between 6,000 and 7,000 yards. North drive extended to 497 feet from main shaft; no ore in face.

Fifth half-year, ending 30th June, 1906.—Only two furnaces constantly employed, others being closed down alternately for extensive repairs. No. 5 furnace in course of erection. No. 1 furnace being replaced by one of larger type. Winding-engine, air-compressor, rock-drills, &c. installed. Main shaft, 485 feet. North drive at No. 3 level (370 feet) 422 feet; still in ore. Jigging plant, to treat 15 to 20 tons per day of accumulated fines, in course of erection.

Sixth half-year, ending 31st December, 1906.—South shaft, 435 feet south of main, being sunk to prospect southern end of property. New reduction furnace, to replace No. 1, completed. Refinery built. Tram-line and slag trucks installed. Hand-jigging plant completed, but had to be closed, water in shaft failing.

Seventh half-year, ending 30th June, 1907.—Development hampered by industrial troubles. South shaft, 105 feet. Small blast furnace begun in March for experimental purposes. Blast furnace of 100 tons capacity being delivered. Main shaft, 563 feet. Krupp Ball mill added to plant for crushing quartz for brick-making, fettling, &c. Refinery started—copper despatched as refined ingots.

Eighth half-year, ending 31st December, 1907.—No. 1 level (150 feet), length of proving, north 483 feet; No. 2 level (250 feet), length of proving, north 543 feet; No. 3 level (370 feet), length of proving, north 438 feet; No. 4 level (470 feet), length of proving, north 516 feet; total sinking, 1,780 feet; total driving, 2,726 feet; total cross-cutting, 522 feet. No. 2 furnace rebuilt. Small blast furnace run for forty days at 11½ tons per day. 100-ton blast furnace being erected.

No ore stoped south of main shaft. Channel filled with pyritic ore, poor and silicious.

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COBAR MINING DISTRICT—*continued*.

No trace of copper was found in the 105 feet shaft, 435 feet south of the main shaft. No stoping south of main shaft.

The lode varies in thickness in the different levels from 1 foot to over 20 feet wide, intermixed with bands of country. In places proved solid for 5 to 10 feet wide. Best ore lens about 120 feet long, width about 3 feet.

At 450 feet level an east lode struck in crosscut about 15 feet from main lode. Width, 2 feet; ore, 4 to 5 per cent.

A large body of slightly impregnated country, 30 feet wide, carrying about ½ per cent. of copper, occurs 70 feet west of main lode.

The general lodestuff at Queen Bee consists of slate with copper and iron pyrites, and an inappreciable quantity of zinc-blende and galena. It is broken and hand-picked over shaking tables before going to furnaces. It carries 1 to 2 oz. of silver per ton, but no gold.

The reverberatory plant embraces four reducing and one refining furnaces of a capacity of about 70 tons per week each, one being occasionally worked to 100. The first run matte averages 40 to 42 per cent. copper.

The small blast furnace, running on the best grade ore, with limestone and ironstone fluxes, averages about 11½ tons per day, producing matte of 31 per cent., at a cost of £2 per ton of ore for smelting, according to the company's eighth half-yearly report; the charge being :—

Coke	100 lb.
Raw sulphide	350 ,,
Slag	120 ,,
Limestone	150 ,,
Ironstone	50 ,,
	770 lb.

The coke and fluxes being slightly increased when slag runs thick.

In view of the above results, with carefully-picked best grade (most pyritic) ore, the erection of a 100-ton blast furnace appears unwise. The best ore only can be treated by this method at excessive cost for coke and fluxes. Limestone and ironstone costing 10s. per ton for cartage. The Queen Bee ore on the average is too silicious for ordinary blast furnace reduction.

The limestone flux is obtained on the Rookery-road, about 11 miles from the mine; its composition is shown in the following partial analysis :—

No. 07-7430—Calcium carbonate	99·03
Gangue	·53
Ferric oxide and alumina	·14
Magnesium carbonate and undetermined	·31
	100·00

OUTPUT from June, 1902, to 31st December, 1907.

Year.	Ore raised.	Ore sold.	Ore smelted.	Rough copper produced.	Remarks.
	Tons.	Tons.	Tons.	Tons.	
1902	383	83*	.....	.....	*Sold for £497.
1904	1,469(?)	319*	1,150	136½	*291 realised £2,292.
1905	7,854	.....	5,383	499¾	
1906	11,556	.....	7,158	573	
1907	10,235	.....	6,422	493¼	
Total	31,497	402	20,118	1,702½	

Dividends Nos. 1 to 13 paid, aggregating £15,625 to end of 1907.

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COBAR MINING DISTRICT—*continued.*

Bobadah Division.

Recovery Copper Mine, Top Tank Paddock, Overflow, 18 miles north-east of Overflow Silver-mine.—Held as a mineral lease of 40 acres. Shaft sunk 100 feet, and driven east 45 feet. The vein occurs in soft micaceous slate and sandstone, and consists of ferruginous quartz with a little copper and lead carbonates, about 12 to 18 inches thick. Assays of picked samples ($\frac{1165\text{-}6 \text{ and } 1634}{97}$) yielded from 15 to 42·5 per cent. of copper. The vein is reported to have pinched out or been lost in sinking. A few dwts. of silver, and, in one instance, 19 dwts. of gold per ton, have been obtained in assays.

Aided in 1906 (P.B. $\frac{1\,8\,7\,8}{0\,6}$) to drive 100 feet north on lode at 100-feet level.

At 50 feet in drive, vein of copper showing 3 to 20 inches wide, country also showing stains of copper ore. End of drive not promising. Drive abandoned. Aided to continue shaft to 200 feet.

Canbelego Division.

South Budgery.—On south boundary of Budgery Mine. Vertical shaft within 30 feet of boundary of latter. Down 213 feet at date of inspection, November, 1907. No ore discovered so far.

South Mt. Boppy Copper Mine.—Adjoining M.L. 51 on the south-east. One shaft sunk at junction of porphyry and sedimentary rocks, showing bleached and kaolinized deposit. No ore. West shaft sunk in ferruginous slate outcrop. Encouraging results obtained in 50-feet shaft; 3 or 4 per cent. carbonate ore being raised in some quantity, with bands of richer ore. Worthy prospecting below water-level.

In the adjoining block (M.L. 51) in north shaft, a similar deposit of puggy, ferruginous, and manganiferous kaolin occurs as in the Restdown Mine, probably arising from secondary action of leaching and depositing solutions following the intrusion of the porphyry.

Cobar Division.

South Queen Bee, M.L. 32, parish Narri, county Robinson.—Inspector Polkinghorne reports that this site was taken up in 1902, after discovery of the adjoining Queen Bee Mine. Two shafts sunk, No. 1, 296 feet, No. 2, 175 feet; about 1,000 feet apart. Traces of copper only discovered.

Nymagee Division.

Star of the West Mine (formerly Wirlong), about 5 miles east of Shuttleton and 14 from Nymagee, parish Hume, county Mouramba.—Discovered in 1898 by Morris and Kelly, in porphyry near junction of slate. Strike N. 10° E.; dip S. 80° E. Three small veins exposed at intervals of about 150 yards. Shaft on one vein to 58 feet. Aid granted to continue sinking and to crosscut.

Inspector J. Polkinghorne reported (P.B. $\frac{1\,9\,1\,1}{0\,1}$) ferruginous quartz in slate and porphyry. Aided to sink 30 feet shaft to 100 feet, and to crosscut 50 feet east and west.

First ore recorded at 25 feet west in crosscut, carbonates about 1 foot wide, equal to about 10 per cent.

The same officer reported (P.B. $\frac{1\,5\,4\,7}{0\,7}$) that both crosscuts—in previously aided prospecting—passed through a mineral body, and at 23 feet from the

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shaft in the west crosscut some good-looking veins of grey ore and carbonates are exposed, underlying east. Aided to sink from 30 to 200 feet, and crosscut 50 feet at that level—east and west.

At later date prospects were reported as poor, and work ceased.

Bobadah Division.

Walker's Hill, 1 mile north of Walker's Hill Homestead and 16 miles from Bobadah.—Copper ore occurs here in slate and sandstone. Aid was granted from the Prospecting Vote to sink 65 feet and drive 40 feet on a number of leaders from 1 to 4 inches thick, similar to those occurring in an old shaft about 110 feet south. The results obtained under aid were not encouraging, no improvement in the ore veins being manifest.

Geological Surveyor A. J. Watt reported (P.B. $\frac{4}{6}\frac{8}{6}\frac{1}{1}$) copper lode traversing slate. Aided to sink 50 feet from bottom of 15-feet shaft. Leaders of copper ore in bottom of shaft.

Progress.—In drive at 61 feet stains of carbonate in slate. Aided to crosscut 50 feet. Country hard, and mineralised with leaders of copper ore. Aided to continue 68-feet shaft another 30 feet. Vein widening, sulphides more pronounced. Further aided to 128 feet. Ore channel reported wide, with several small leaders of ore. Crosscut 28 feet at bottom. Strings of ore only.

Nyngan Division.

Wilgarbone.—No. 1 Prospecting Area, A. Leslie's Settlement Lease, parish Wilgarbone, county Canbelego, about 8 miles from Girilambone.

Traces of carbonate of copper in chlorite schist. Aided to sink to 150 feet and crosscut. Very poor indications of payable deposit.

Bobadah Division.

Yellow Mountain, M.L. 1, 15 miles southerly from Bobadah.—At the north end of Yellow Mountain, which consists of quartz-felsite, Byrum Bros. discovered three outcrops of ferruginous carbonate of lead of very kindly appearance. In one of these a little copper ore occured—red oxide, and traces of carbonate; but the chief value was in silver and lead. The two principal deposits form bunches on the surface from 18 to 20 feet long, and 6 to 7 feet wide; beyond the bunches the lodes continue, but are thinner. The principal bunch, containing the copper ore, was followed down 40 feet, where it is from 2 feet to 2 ft. 6 in. thick. There is every indication of the lode continuing to form lenticular bunches. Six tons of the ore sent to the Smelting Company, Dapto, yielded 9 per cent. of copper, 45 per cent. of lead, and 33 oz. of silver and a few dwt. of gold per ton. This bunch occurs in slate between quartz porphyry; the other in the porphyry.

Aided in 1903 (P.B. $\frac{1}{0}\frac{8}{3}\frac{8}{3}\frac{0}{0}$) to sink from 62 feet to 112 feet, and to drive 50 feet. No record. Further aid for 100 feet of sinking in winze at 100-feet level. At 150 feet sulphides reported as showing freely. Abandoned.

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HUNTER AND MACLEAY MINING DISTRICT.

Port Macquarie Division.

Huntingdon Mines.—In bed of Hastings River, portion 7, parish Koree, county Macquarie, 17 miles from Port Macquarie.

For over twenty years metalliferous ores were known in the remarkable rugged outcrop of quartz-felsite which forms rapids in the river for over 400 feet, and rises like islands above the channel gravel bed.

First opened by Messrs. Cummins and Campbell about 1905. A shaft was sunk in an island of felsite in the centre of the river, to a reported depth of 38 feet, no ore being obtained.

Part of the material pierced consisted of a fine cherty rock, described by Mr. Card as "probably an indurated volcanic ash." The latter contained iron pyrites.

A small engine and pump were employed during operations.

On the opposite side of the river another syndicate sank a shaft 50 feet, but off the quartz-felsite and in the intruded slate. The apparent strike of the former is N. 40° W.

The outcrop in the river is large, but the average percentage of ore is very low.

The ore obtained was all from the one original outcrop of lode matter in the river. It consists of a low-grade refractory mixture of zinc-blende (principally), copper and iron pyrites, and galena, in quartz.

An average sample of picked ore yielded:—

No. 07-4514—Copper	1·27	per cent.
Zinc	23·28	,,
Lead	2·76	,,
Gold	a trace	per ton.
Silver	1 oz. 5 dwt. 1 gr.	per ton.

An outcrop of Permo-Carboniferous (Lower Marine) limestone occurs at no great distance—in M.L. 2, parish Koree, county Macquarie, about 2 miles from Wauchope. Strike, N. 70 E. Fossils abundant.

Its composition is given in the following analysis:—

No. 07-4513—Moisture	0·12
Carbonate of lime	93·39
Carbonate of magnesia	4·31
Ferric oxide and alumina	0·65
Gangue	1·70
	100·17

Trace of copper detected.

Kindie.—Hastings and Forbes River district.

Mixed copper, lead, zinc, and silver ore in 6-inch vein, opened by Bethune and party. Assay value:—

Copper	1·5 per cent.
Lead	39·0 ,,
Silver	16 oz. per ton.

Aid recommended by Inspector D. Milne, but not availed of.

Kempsey Division.

Long Flat.—Copper sulphides in quartz have been reported at Long Flat, 63 miles above Kempsey, on the Macleay River. Unopened.

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Hunter and Macleay Mining District—*continued.*

Port Macquarie Division.

Mount Jasper Copper Mine, M.L. 1, parish Jasper, county Macquarie. About 40 miles from navigable water at Beechwood, Hastings River. Discovered by A. Muir in 1887.

Four lines of lode have been discovered, striking from north and south to N. 55° W., and dipping westerly 35° to 55°.

The centre lode received aid for sinking in 1901 (P.B. $\frac{2}{0}\frac{1}{1}\frac{1}{1}$). Work commenced in 1902.

In 1904 the mine was worked by tributers; average width of lode, 3 feet.

In 1905 the shaft reached 100 feet; lode, 4 feet wide. Carbonate ore at 50 feet.

Taken under option by the Mount Jasper Mining Syndicate, which held possession for about fifteen months, but did little towards proving the lodes in depth.

Inspected by the Writer in 1907. The lodes occur in a high range on east side of Jasper Peak, at an elevation of about 1,000 feet above the Forbes River at its base.

The country consists of Permo-Carboniferous Lower Marine beds intruded by dioritic and peridotic rocks, changing to serpentine.

No. 1 or centre lode—opened to 100 feet; driven on south for 25 feet at 90-feet level. Not open to inspection owing to water. Strike N. and S.; dip west at 55°. A little sulphide ore showing at 25 feet; but no workable ore encountered above 60 feet. The ore—quartz and chalcopyrite—pinched to 1 ft. 6 in. wide at end of drive, but varied up to 4 feet wide at best. About 70 tons despatched from this shaft yielded from 10 to 23 per cent. of copper. The first 3 tons yielded also 8 dwt. 19 grs. of gold and 2 oz. of silver per ton. No further payments made for gold.

The composition of the best grade of Jasper ore was found to be:—

Copper	23·4 per cent.
Iron	23·4 ,,
Sulphur	22·9 ,,
Silica	18·9 ,,

No. 2 or "East Lode."—About 9 chains S. 40 E. from No. 1; has been opened by two shafts 50 and 70 feet deep. This lode consists of solid quartz about 3 feet wide, carrying small particles and patches of yellow sulphide of copper. Strike, N. 20° W.; dip, S. 70° W. at 74°. The lode has been driven on 30 feet at the 50-feet level. Of no value as a copper lode.

No. 3 Lode.—Two chains N. 50° W. from No. 1 lode, a 10-feet shaft has been sunk in an outcrop striking N. 40° W., and dipping south-west; 3 feet to 5 feet wide; shows copper carbonates of 3 to 5 per cent. grade.

No. 4 Lode.—Nine and a half chains south-west of No. 1. Strike N. 55° W.; dip S. 55° W. at 35°. Opened by tunnel and shallow shaft. Width of channel, 1 foot to 12 feet; mostly filled with crushed peridotite or serpentine, in which occur bunches and kernels of good yellow sulphide and iron pyrites. Wall rocks hard, forming prominences in places.

Ore good when clean, but silicious as dressed. Twelve tons despatched from this lode averaged 15 per cent. of copper.

Underfoot in the tunnel about 1 foot 3 inches of good ore continues; balance, hornblendic rock with kernels of ore.

Mr. T. McLelland states—10th January, 1908—that little work has been done on these lodes since inspection.

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Copper ore is reported in Andrew's block, about 1 mile south of Mount Jasper Mine, but has not been prospected.

Mount Jasper Peak Lode.—W. H. Taylor's prospecting area. About 50 chains S. 80 W. from Mount Jasper Mine. Quartz lode carrying a little carbonate and sulphide of copper. Strike, apparently N. 40° W.; dip, S.W. at 71°. Aided to intersect by tunnel about 170 feet below highest outcrop. From old workings and present operations, apparently no permanent ore body exists.

Singleton Division.

Mount View, Pokolbin.—Messrs. Pepper and party did a good deal of prospecting for copper ores in the inlier of old rocks forming Mount View, but the results were not promising for a payable deposit.

The following samples were received in the Departmental Laboratory for assay:—

Assay No.	Description.	Copper per cent.	Gold per ton.	Silver per ton. oz.	dwt.	grs.
06-3866	Copper ore	10·82	4 dwt. 8 grs.	3	16	8
06-5548	Ferruginous granitic rock with copper carbonates and sulphide—20-feet level.	13·72	a trace	3	16	5
06-5549	do do do ...	1·17	do	1	7	5
07-2230	Copper pyrites, with chlorite	32·45	do	6	10	16
07-4151	Copper pyrites, with chlorite and tourmaline.	7·25	2 dwt. 4 grs.	3	0	23

Inspector D. Milne reported (P.B. $\frac{1}{0}\frac{8}{3}\frac{2}{3}\frac{8}{8}$) that a small bunch of copper ore occurred in granite at this site—4 ft. long, 3 ft. deep, and about 3 inches thick. After this cut out no further sign of copper was met.

Port Macquarie Division.

Port Macquarie, south of Nobbys, the south headland of Port Macquarie.—A lode containing iron and copper sulphides was opened about twenty-six years ago by tunnel from the sea coast, without, however, any satisfactory results being obtained. Assays of the lodestuff in 1880 yielded from 2·13 to 5·05 per cent. of copper, and about 2 dwt. of silver per ton.

Rose Hill Mine, portion 7, parish Koree, county Macquarie On east bank of Hastings River, just above Huntingdon Mine, near Wauchope.—Cummins and party opening lode striking E. and W., dip N. at 73° in quartz-felsite. Opened by tunnel from river bank; traces of copper and iron pyrites and zinc-blende beginning to show at 20 feet.

Kempsey Division.

Willi Willi Copper and Silver Mine, M.Ls. 1 and 2, about 7 chains south of south-west corner of portion 17, parish Panton, county Dudley.—About 37 miles from Kempsey. About 1,300 feet above sea level, and 465 feet below the gap in range between it and Willi Willi Station, the rise to the gap from the latter being about 1,295 feet.

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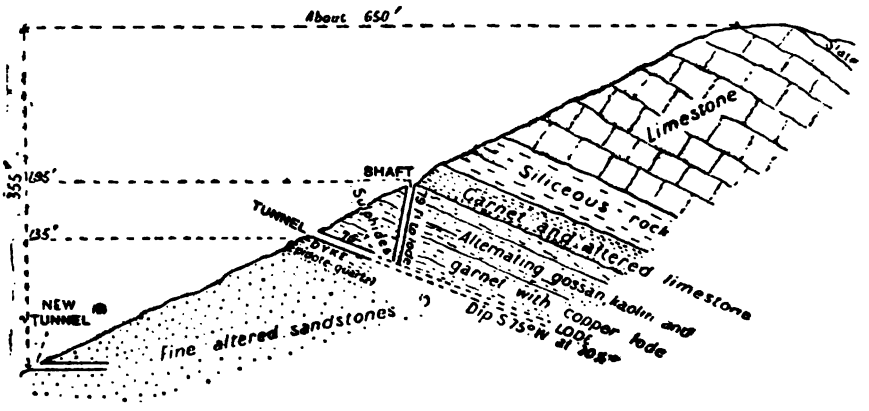
Formation—Permo-Carboniferous dolomitic limestones, altered claystones, and sandstones, with intrusive epidote-quartz rock (6984). Rich bunches of copper carbonates were discovered near the junction of the rocks mentioned with the igneous intrusive rock. Masses of garnet have resulted from the contact of the latter with the limestone; also wollastonite (silicate of lime).

The following section across the strike of the country illustrates the mode of occurrence of the lode in M.L. 1 and its association.



Copper ore was discovered in this locality by H. H. Mansfield about 1891. At the first site—in limestone—aid was granted to sink 80 feet, and drive 50 feet, but the surface ore was found not to extend below 26 feet. Four tons sent to Wallaroo Smelting Works, South Australia, yielded 7 per cent. of copper and 73 oz. of silver per ton.

About 25 chains S. 80° E., a more promising outcrop was discovered at the junction of an intrusive dyke. A number of short tunnels were driven along the junction line, and 57 tons of rich ore extracted from bunches in the lode.

Between the two outcrops a third occurs, which has also been prospected under aid, but not with payable results.

The best results have been obtained, and the most favourable indications occur in the contact lode. The sulphide zone, however, requires effective proving before the real value of the deposit can be ascertained. A considerable amount of leaching has occurred in the oxidised cap. The character of the ore bunches found in the latter can best be judged from the following assay returns, made in 1894; the silver occurs in the form of chloride:—

Copper gossan,	No.	1717	—copper,	37·66	per cent.;	silver,	163	oz.	3	dwt.	16	grs. per ton.
Carbonate	,,	1491	,,	29·28	,,	,,	23	,,	3	,,	9	,, ,,
,,	,,	2413	,,	36·94	,,	,,	107	,,	7	,,	8	,, ,,
,,	,,	2414	,,	49·67	,,	,,	118	,,	2	,,	22	,, ,,
,,	,,	2415	,,	16·15	,,	,,	46	,,	1	,,	3	,, ,,
,,	,,	3418	,,	31·71	,,	,,	283	,,	15	,,	6	,, ,,

Mr. Mansfield states that he despatched 50 tons to Harold Bros., Adelaide, between 1893 and 1894, which realised 33 per cent. of copper and 63 oz. of silver per ton. Seven tons sent to Lithgow yielded 18 per cent. of copper and 25 oz. silver per ton.

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Baker Bros.—who subsequently held the mine, drove Mansfield's tunnel in M.L. 1 to 75 feet, and struck sulphides as per assays 07–5304 and 5305—are reported to have despatched 33 tons. They abandoned it in 1901 and removed plant. A Kempsey Syndicate afterwards sank a shaft 50 feet hgher up the ridge, and struck the lode on the underlay at 79 feet, encountering sulphides as per Assay No. 07–5306.

This lode strikes N. 15° W., and dips S. 75° W. at about 20½°. The following section is exposed at the tunnel mouth, where a cut face has been made along the outcrop between the various tunnels:—

In descending order.

15 feet { Gossan, with pipeclay.
Garnet.
Copper ore.
Garnet.
Tunnel level.

A lower tunnel was started early in 1907 by the present holder (W. H. Trewenack) 135 feet lower down eastern slope; but as the lode dips flatly in the opposite direction, at least 500 feet will have to be driven to intersect it at not more than 100 feet below the present lowest upper tunnel level. Though the soakage water may be a little troublesome on such a flat underlay, it would be best to continue the upper tunnel or start a straight shaft higher up the ridge to cut the lode further west. The height of the ridge and the dip would not exceed the distance of the present tunnel, and would give a considerable amount of backs, which the latter will not.

Four short tunnels were driven in the outcrop by Mansfield, and these were slightly extended by Baker Bros., the total length opened along the crop between the extreme northern and southern tunnels being about 190 feet.

Mining for the rich argentiferous copper carbonate bunches, which occurred more or less isolated, resulted in excavation of large irregular chambers and erratic drives and cross-levels.

In the southern, or No. 4 tunnel, kaolin is largely developed, in which petaloidal structure has been developed by compression and thrust. A remarkable feature is the occurrence in it of isolated bunches and kernels of pure garnet. The copper carbonates are associated with this mineral to a considerable extent, especially when highly ferruginous.

The sulphide ore struck in the principal tunnel and in the vertical shaft consists largely of magnetic and ordinary pyrites, with chalcopyrite and secondary veins of arseniopyrite, in vitreous altered rock with occasional calcite.

In M.L. 2, on the west, the original site of discovery at Willi Willi, a tunnel was driven 110 feet S. 15° W. towards the middle shaft, two veins of bornite being cut in chalcedonic quartz and limestone, with garnet and wollastonite. An average sample of the ore stacked at the tunnel mouth yielded as per sample No. 07-5307; but the available quantity was too small for profitable extraction. A ton of similar ore raised from the middle shaft some years ago is reported to have yielded 40 per cent. of copper and 35 oz. of silver.

In the adjoining lease (M.L. 4) on the north, on Block and Tackle spur, an opening in a gossany outcrop, with stains of copper carbonate, revealed below the sphere of oxidation a fine greenish garnet rock, with idiogenetic copper ore, the joints of which were covered with a film of shining iron

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oxide. An assay of several pieces revealed gold at the rate of 1 oz. 12 dwt. 16 grs. per ton, apparently due to inclusion of a rather coarse unnoticed particle; for several subsequent tests failed to reach above a few dwts.; as it contained, in addition, up to 1·62 per cent. of copper, it may prove a useful flux.

From another large outcrop on the same block a sample was taken, consisting of massive pyrrhotite and a little copper pyrites, which yielded the results shown in Assay No. 07–5308.

Assay No.	Description.	Copper, per cent.	Iron, per cent.	Sulphur per cent.	Silica, per cent.	Gold, per ton.	Silver, per ton.
							oz. dwt. grs.
07–5304 ..	Average sulphides, Old Tunnel, M.L. 1.	1·57	....	....	.. .	trace	2 4 15
07–5305 ..	Enriched sulphides, Old Tunnel, M.L. 1.	13·40	....	....	....	,,	15 19 1
07–5306 ..	Average sample from New Shaft, M.L. 1.	2·55	28·28	21·09	20·79	,,	2 0 20
07–5307 ..	Average sample from New Tunnel, M.L. 2.	11·90	(Lime,	15·19)	31·90	,,	35 14 7
07–5308 ..	Average sample from pyritic outcrop, M.L. 4.	1·05	....	....	....	,,	0 15 6

The composition of the dolomite from M.L. 1 is shown in the following analysis (07–5319):—

Calcium carbonate	57·99	per cent.
Magnesium carbonate	39·98	,,
Ferric oxide and alumina	·60	,,
Gangue	1·18	,,
Strontia	trace	
	99·75	,,

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LACHLAN MINING DISTRICT.

Condobolin Division.

Anaconda Mine, about 30 miles northerly from Condobolin Railway Station, parish Melrose, county Cunningham.

Under the name of Boone West, this mine was opened about nineteen years ago, but as far as prospecting then went, a payable lode was not revealed. After being abandoned for a number of years, it was taken up and floated into a no-liability company, active prospecting operations being carried on in October, 1898.

The country consists of ferruginous slate and much crushed conglomerate At the surface, copper carbonates occur sparingly in the latter. A shaft was sunk 100 feet deep on the west of the outcrop, and a cross-cut driven to it. The ore channel at the junction of the conglomerate is filled with soft chlorite with greasy headings. In places a little native copper appears, and thin films of red oxide in the jointings. A thin seam of pyrites occurs, but is almost, if not quite, free from copper sulphide. A little grey sulphide was found in sinking and driving, but not in quantity. Magnetic iron is present in bright micaceous particles, which may be confounded with copper glance. No payable ore was exposed along the southern drive at the 100-feet level.

Recent developments.—Taken up by Mr. G. Eason in 1902 after being idle for two years (Ann. Rept., 1902, p. 50). A little surface prospecting done in 1904 (*ibid.*, 1904, p. 47), and about 150 tons of ore disposed of.

In 1905, sulphides reached at 290 feet reported to yield 3 per cent. copper, 2 dwt. gold and 3 oz. silver per ton. Four hundred tons of ore raised (*ibid.*, 1905, p. 45).

A little desultory work done in 1906 (*ibid.*, p. 47).

Inspector G. Smith reported in the latter year that the depth of proving was 300 feet and the length 200 feet.

About 30 tons raised.

Molong Division.

Armstrong Copper Mine, parish Yetholme, county Bathurst.—In the *Mineral Statistics of New South Wales*, 1875, p. 92, it is recorded that a company was engaged working the above mine, and the following particulars are given:—Strike of lode E. and W.; dip slightly north; thickness at surface, 2 feet, gradually increasing to 4 feet 6 inches at 50 feet. The ores consisted of red and black oxides, carbonates, and sulphides, assays of which yielded from 15 to 36 per cent. of copper; 60 or 70 tons of ore were then at grass. The intention of erecting smelting works on a new American principle was expressed. No further particulars of this mine are recorded, at least not under its original name.

Grenfell Division.

Arramagong.—In 1890 Mr. W. Anderson, Geological Surveyor, recorded the presence of blue and green carbonates of copper in the argentiferous lead lode opened by the Great Southern Silver-mining Company, in C.P. 17, parish Tyagong, county Monteagle, between Young and Grenfell. A small quantity of silver-lead ore was raised, but operations were soon abandoned.

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LACHLAN MINING DISTRICT—*continued.*

Gundagai Division.

Back Creek Station, near Kimo.—A copper lode was opened in this locality by Engellen and others, of Gundagai. At surface about 1 foot 6 inches thick of good ore, bornite, occurred. A shaft was sunk 50 feet, but the ore pinched out at that level.

Molong Division.

Bell River.—In April, 1852, Stutchbury mentioned copper lodes close to the Bell River, in the neighbourhood of Molong, having a thickness of 5 to 7 feet, which he regarded as well worthy investigation.

Mandurama Division.

Belmore Copper Mine, Woodstock.—This mine was discovered about 1867. The ore consisted of red oxide at surface from 6 to 12 inches thick. Eighty tons were sent to the Cadia Smelting Works (near Orange), averaging, undressed, 37 per cent., according to report. The mine was afterwards sold for £400. The new proprietors sank three shafts from 60 to 90 feet deep. Fifteen tons of rich red oxide, raised during operations, are reported to have averaged 64 per cent. at the Lithgow Smelting Works. The ore cut out in depth, but was making again, though much mixed with quartz.

No further attempt has been made to re-open this mine.

Condobolin Division.

Big Ben Copper Mine, Melrose, about half a mile west of the Anaconda Mine. As at the latter mine, the geological formation consists of slate and conglomerate, with the addition of quartzite. The mine is situated on the summit of a small hill, where a little copper-staining is visible. It was first discovered about nineteen years ago, and was prospected about the same time as the Anaconda—then the Boone West. Aid from the Prospecting Vote was granted to continue the prospecting shaft to the 120-feet level, and to cross-cut west through the conglomerate. No payable ore was discovered during these operations. In the beginning of 1899 it was announced that a company had been formed to re-open it.

Taken up by G. Eason in 1902—but apparently without effect.

Burrowa Division.

Binalong.—In portion 117, near boundary of portion 118, about 6 miles from Binalong, parish Harden, county Harden, copper carbonate stains occur in a small outcrop of porphyry. Opened for a few feet many years ago, but now mullocked up. Not traceable from this point. Specular iron near by, but unconnected. Unimportant.

Copper ores also occur in the Town Reserve at Binalong, but nothing of a workable nature has been proved. Samples taken from old shafts sunk for gold are reported to have yielded from 7 to 30 per cent. of copper on assay.

Condobolin Division.

Blue Bell Mine.—Portion 11, parish Condobolin, county Cunningham, $2\frac{1}{2}$ miles north of Condobolin.

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LACHLAN MINING DISTRICT—*continued.*

Inspector G. Smith, in 1906, reported that this lode was discovered by J. Sinclair, about 1898. It strikes E. and W., and dips S. in schist. Maximum length of proving, 50 feet; depth, 96 feet.

Present owners despatched 22 tons of ore, averaging 7½ per cent. of copper and 4 dwt. of gold per ton.

Grenfell Division.

Boori Copper Mine.—Portion 40, parish Bumbaldry, county Monteagle, in James McMahon's private land.

Inspector H. Hooke reported (P.B. $\frac{26}{07}$) a well-defined channel of considerable length, from which small bunches of copper ore are obtainable. Aided to sink from 31 to 81 feet, and to drive 25 feet at bottom.

Cudal Division.

Bowan Park.—Six miles north of Cudal, portion 281, parish Bowan, county Ashburnham. J. Berta sank two shafts in this property, 35 and 40 feet, on a copper-bearing vein from 1 to 3 feet wide. A few tons of ore raised, but none disposed of. Assays gave from 6 to 18 per cent. of copper.

Cowra Division.

Broula, on Cowra-Grenfell road.—The Lyndhurst Railway and Mines, Limited, raised about 300 tons of about 3 per cent. copper ore from the old Broula copper shaft during 1904, for use in their smelters at Junction Reef, but soon abandoned operations, sufficiently solid bodies of ore not being encountered.

Grenfell Division.

Bumbaldry.—Parker, Smith, and McLeod's copper lode at Bumbaldry, about half a mile south of Cowfell Copper Mine. In 1903, O'Brien and party discovered a copper lode on McMahon's private land at Bumbaldry. 30 tons treated at Dapto reported to have yielded satisfactory results.

Bumbaldry.—Between Cowra and Grenfell. Inspector Hooke reported (P.B. $\frac{20}{04}$): Copper-bearing formation of some width (6 tons of ore from which yielded 10 per cent. of copper) near Bumbaldry Battery. Aid subsequently granted for sinking from 75 feet to 125 feet; apparently not availed of.

In the following year it was reported (Ann. Rept., 1904, p. 45) that £188 worth of ore was disposed of, the lode being from 1 foot to 10 feet wide, and the grade running from 8 to 18 per cent.

(*See* Cowfell Mine, with which this is probably identical.)

Cudal Division.

Bumbery Copper Mine, also known as Reedy Creek and Payne's Mine, 9 miles south-easterly from Bumbery Railway Station.—This lode was originally opened as a gold-mine in 1896; the outcrop consists of gossan, from 40 to 50 feet wide. At 30 feet carbonates and grey sulphide of coppor were struck. The following parcels of ore were treated during prospecting work:—10 tons sent to Lloyd's Smelting Works, Lithgow, yielded 26½ per cent.; 3 tons sent to the Smelting Company of Australia's Works, Dapto, yielded 36½ per cent. In February, 1899, the Writer inspected the mine, which was then being worked by the original proprietors—Payne and party—the holders of a purchasing option having forfeited their deposit.

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The deepest shaft was then 130 feet, but the oxidised zone had not been penetrated. Rich bunches of secondary ore—copper glance—were struck on resuming operations, from which the following returns were obtained at the Smelting Works, Dapto:—

4 tons	14 cwt.	"Firsts"	yielded	42·6	per cent. of copper.
4 ,,	16 ,,	"Seconds"	,,	27·8	,, ,,
2 ,,	10 ,,	"Thirds"	,,	21·8	,, ,,

In the north shaft (130 feet) a large body of gossan was exposed, in which crystalline native copper occurs in places from redeposition from solution. The rich copper glance occurs in bunches in the gossan at 130 feet. Crosscuts have been driven east and west from 40 to 50 feet, revealing a very large body of oxidised material; but the extension of the eastern drive at the 100-foot level for a considerable distance into the solid country was labour in vain.

The south shaft was sunk 112 feet, and crosscut 40 feet east. Here the outcrop consists of red jasperoid altered rocks, heavily charged with pyrites. Epidote rock is also in proximity. Quartz porphyry predominates.

Prospecting was continued in 1900, the main shaft being carried down to 250 feet. Some rich grey ore in small bunches were encountered, several parcels being sold for £413. The grade reached nearly 50 per cent. in some cases.

In No. 3 shaft quartz and ironstone persisted to 86 feet; then black decomposed slate, with native copper of average low grade. Nothing important struck until 234 feet level, where some rich purple ore was met in a 4-inch vein. Shaft timbered up from 250 feet.

At 240 feet a crosscut was driven west 100 feet through low-grade formation without true walls, and east for 34 feet, the first 4 feet in very hard slate, with splashes of grey ore. The east crosscut is reported to have cut through 14 feet of pyrites containing only traces of copper.

Water encountered at 180 feet level, but none in bottom of 250 feet shaft.

Payne's shaft was driven 50 feet at the 50 feet level in soft gossan, without encountering anything payable; 10 feet south, at the 60 feet level, payable carbonates 1 foot 6 inches wide were met; crosscut driven 24 feet west at the 98 feet level. From this level a winze is reported to have been sunk 12 feet in high-grade black ore; width, 4 feet at top, but pinching to 5 inches at bottom of winze.

Burrowa Division.

Burrowa District.—Inspector James reported (P.B. $\frac{2\,4\,3\,1}{0\,3}$) a copper lode in felspathic rock in portion 129, parish Ware, county King, about 12 miles east of Burrowa.

Opened many years ago to a depth of about 100 feet at a point about 350 feet from present site. Object of operations to prove extension of old Wallah Wallah copper lode. Aided to sink from 34 to 77 feet; progress, at 68 feet, slight copper stains in broken country. At 84 feet small veins showing; further aid granted to crosscut 50 feet; no further record.

Right-hand Creek, west side, on D. Flannery's land, 2 miles from Godfrey's Creek Post-office, parish Warallen, county Monteagle.

Bachelor's Reef, 11 miles south-east of Burrowa, and 6 miles south of Rye Park. Quartz vein with lean copper sulphides; not worked.

Democrat silver-lead mine, on Burrowa River, near Kangiara. A little copper ore present in lode; copper strings in hard quartz-felsite outcrop in river bank and near mine; too thin and separate to be of value.

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A few chains down stream thin strings of galena occur under like conditions. Near the latter a shaft has been sunk by Reynolds and others to a reported depth of 60 feet, from which some tons of ore are reported to have yielded 9 per cent. copper and 25 dwt. of gold per ton. This lode is seen crosing the river bed about 10 chains northerly where it occurs in a bar; a little copper and iron pyrites are visible leanly distributed in quartz-felsite.

Cargo Division.

Cargo.—W. Anderson, Geological Surveyor, pointed out that in the lower levels of the Ironclad Mine, Cargo, solid iron and copper pyrites occurred, and that generally the ore was more freely gold-bearing where the copper was most plentiful. (Ann. Rept., 1890, p. 268.)

In 1888 a copper lease was taken up by Gazzard and party, between the Ironclad and Dolcoath Mines. 10 tons of ore from the Ironclad Mine were sampled and assayed at the Government Metallurgical Works, Clyde, with the following result:—

Copper	2·97 per cent.
Gold	19 dwt. 2 grs. per ton.
Silver	1 oz. 5 dwt. 5 grs. per ton.

Cudal Division.

Cheeseman's Creek.—At Dairy Hill, ½ mile from Orange to Forbes-road, 17 miles west of Orange, parish Boree Nyrang, county Ashburnham. Inspector Smith reported (P.B. $\frac{2}{0}\frac{8}{7}\frac{2}{2}$), copper-bearing felsite at this site, a sample of the rock assaying copper 4·7 per cent., and gold 3 dwt. 16 grs. per ton. Aid granted to sink 50 feet from bottom of 10 feet shaft, following the copper ore. Subsequently abandoned; country hard; prospects not encouraging.

Condobolin Division.

Condobolin Copper and Gold Mine.—Situated about 1½ mile northerly from Condobolin. Opened about 1896 to a depth of 90 feet, under Government aid, in schistose country. The vein has a thickness of from 12 to 15 inches at surface, and 4 inches at 50 feet, and strikes N. 40° E., with a dip S. 50° E. It consists of ferruginous quartz, with a little copper carbonate and grey sulphide. Six tons raised during operations yielded 11 per cent. of copper and a trace of gold at the Australian Smelting Company's Works, Dapto. About a quarter of a mile west copper ore was discovered and followed down 90 feet. Vein reported to have been 2 feet thick at surface, but pinched out at 90 feet.

Traces of copper also occur in Shepherd and party's mine to the north-west on the Melrose-road; it makes its appearance in the schist country.

Cootamundra Division.

Cootamundra.—A sample of carbonate ore from 5 miles from Cootamundra ($\frac{1}{0}\frac{2}{4}\frac{1}{1}$) yielded 12·8 per cent. copper; and another from 8 miles N.W. ($\frac{1}{0}\frac{1}{5}\frac{1}{2}$) yielded 16·80 per cent.

The outcrop is not well defined, being mixed through the granite, forming a thickness of about 2 or 3 feet. A shaft, about 60 feet deep, sunk a few feet from the outcrop, evidently cut the lode, as a good deal of copper-stained ore was brought to the surface. A representative sample proved of very low grade.

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LACHLAN MINING DISTRICT—*continued.*

Cootamundra District.—On unused road between portions 235 and 236, parish Dadauman, county Bland (J. Kearns' property). In 1899 a shaft was sunk 60 feet in copper-stained, much crushed quartz-felsite Quartz veins in faces, and in country alongside. Copper stains not traceable away from shaft. Unfavourable.

(BATHURST MINING DISTRICT.—*Canowindra Division.**)

Copper Mine Creek.—Parish Malongulli, county Bathurst. This creek is a tributary of the Belubula River, and drains from Sugarloaf Mountain, in the same parish, near which the Sugarloaf, Smith and McGuinness's, and Rothery's Mines occur. The cupriferous formation is an andesite, and in one mine—Smith and McGuinness's—copper carbonate and native copper occur in the steam holes of the rock, which are now chiefly represented by calcite amygdules.

LACHLAN MINING DISTRICT.

Grenfell Division.

Cowfell Mine.—Portions 52 and 61, parish Bumbaldry, county Monteagle. M. Morrison, Senior Field Assistant, reports that "the ore—blue and green carbonates, red oxide, and yellow sulphide—occuss in bunches in porphyry. No defined lodes have yet been met with. Five shafts have been sunk close together, the deepest being 75 feet; ore was obtained from each.

Aid was granted some years ago for sinking 75 feet and cross-cutting 45 feet. The output from July, 1905, to end of November, 1907, amounted to 230 tons, for an average of 7 per cent. of copper. The gold contents ranged from a trace to 3 dwt. per ton, averaging under 1 dwt. Silver contents from 1 oz. to 4 oz. per ton.

Molong Division.

Delaney's Dyke.—Mr. C. S. Wilkinson reported that at Delaney's farm altered Silurian limestones and chloritic rocks occur, dipping west at 75 degrees. In these rocks a little grey sulphide and carbonates of copper were noted, but not in payable quantity. (Ann. Rept., 1886, p. 133.)

W. Anderson described Delaney's dyke as a garnetiferous rock containing gold and copper. It traverses Silurian slates near their junction with granite; strikes nearly north and south, and dips east at a high angle. Numerous shafts were sunk in the outcrop, the deepest 65 feet. The lode at 40 feet averages 10 feet; at 55 feet it reaches 23 feet, including a "horse" of dark slickensided slate, stained with carbonates of copper. At the south end of the deepest level the lode was reported rich in copper carbonates. (Ann. Rept. 1888, p. 183.)

Canowindra Division.

Eurow Copper Mine.—About 20 miles east of Forbes, and 9 miles north-east of Eugowra. This mine, held as a mineral conditional purchase, portion 80, parish Wise, county Ashburnham, is the original site of Sloan's discovery of copper in the locality about 1881. It is reported that 60 tons of ore were extracted in 1884, which yielded, at the Waratah Smelting Works, 18 per cent. of copper. It was again taken up about 1896, and worked by a syndicate. It adjoins the Vychan Copper Mine, about 300 feet separating the workings. The Eurow was formerly known as Payten's Mine.

During a visit of the Writer in 1898, mining operations had ceased pending the result of treatment of a trial parcel of 20 tons of sulphides which, at the bottom of the workings—89-feet level—were very massive, and almost

* Should appear on page 139.

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entirely iron pyrite. Apparently the result of the trial was not satisfactory as the property was subsequently advertised for sale under a judgment for wages.

In 1901, Mr. Nicol and party worked for several months raising ore, valued at £615. (Ann. Rept., 1901, p. 55.)

In 1903 a reverberatory smelting furnace was erected capable of treating 70 tons of ore per week.

Water for domestic purposes is obtained from springs close to the mine, the Lachlan River being about 8 miles distant.

Inspector G. Smith reported in February, 1907, that the lode had been proved by shafts and levels for a length of 800 feet, and a depth of 132 feet. No record of output is obtainable, but the ore is said to have averaged 8 per cent.

(BATHURST MINING DISTRICT.—*Canowindra Division.**)

Fitzroy Mine.—Parish Malongulli, county Bathurst, near the Belubula River, on Licking Hole Creek, a tributary of Liscombe Poole's Creek, about 16 miles from Canowindra. At this and the adjoining Belubula Mine some of the earliest prospecting for copper in the State was done. In 1845 work was also progressing in the Belubula Mine, according to the late Mr. W. M. Rothery, of Cliefden Station, who also stated that no payable ore was discovered in either.

LACHLAN MINING DISTRICT.

Gundagai Division.

Gundagai Mine.—Portion 205, parish Kimo, county Wynyard, 7 miles from Gundagai.

Veins of quartz occur at this site, showing carbonate and sulphide of copper.

The strikes of two being N. 10° W. and N. 15° W.; at least five others strike about N. 20° to 40° E.

The first or north-western lines have been opened by two shallow shafts and a trench; of the others, two only have been opened by shallow shafts.

From the four principal openings, the following average samples of dressed ore were taken:—

Assay No.	Copper.	Gold.	Silver.	—
	per cent.	per ton.	per ton.	
08-433	8·25	1 dwt. 2 grs.	9 dwt. 19 gr.	N. 15° W. vein.
434	1·27	2 ,, 4 ,,	10 ,, 21 ,,	N. 40° E. vein.
435	8·60	2 ,, 4 ,,	8 ,, 16 ,,	N. 10° W. vein.
436	6·47	2 ,, 4 ,,	10 ,, 21 ,,	N. 40° E. vein.

Parkes Division.

Gunningbland Copper Lode.—On Gunningbland Run, near Trundle road, about 18 miles from Parkes. Inspector E. C. Whittell stated in 1898 that the copper ore—grey sulphide—occurs in the form of scattered threads and small bunches in quartzite, which is associated with limestone, sandstone, and conglomerate. A shaft had been sunk in the quartzite to 50 feet, to which depth no payable ore bodies had been discovered. A bold outcrop of ironstone occurs near by, stained in places with green carbonate of copper.

* Should appear on page 143.

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LACHLAN MINING DISTRICT—*continued.*

Gundagai Division.

Jones' Creek, near Gundagai.—Copper carbonates occurred in serpentine and talcose slate close, to the old asbestos mine. Width, 2 feet at surface, but pinched out at 20 feet.

The assay value is shown in the following assays :—

No. 07-503—Copper, 4·32 per cent.
Gold, a trace
Silver, 4 dwt. 8 gr. } per ton.

No. 07-504—Copper, 1·82 per cent.
Gold, a trace
Silver, 13 dwt. 1 gr. } per ton.

Kangiara, p. 354.

Cowra Division.

King of England Mine.—On a spur of Illunie Mountains, parish Bang Bang, county Forbes, about 17 miles southerly from Cowra.

Chief Inspector J. B. Jaquet reported on this site soon after discovery (Ann. Rept., 1901, p. 166), and furnished the following particulars of development to that date :—

"Illunie Mountains form a continuation of Broula Range. Small specimens of copper ore were discovered here from time to time. In 1900 Peel and Shearsgold began systematic prospecting, and discovered some narrow veins from which a few tons of 8 to 23 per cent. ore were raised.

"In 1901 H. Newham found by chance a rich outcrop of carbonates, striking N. and S. and dipping W. in felspar-porphyry, and extending for 90 feet. About 20 chains further south, apparently on same strike, rock with carbonates was noted.

"The lode in a 29-feet underlay shaft was 2 ft. 6 in. to 3 feet wide, and very rich. At 29 feet the ore was a mixture of yellow and black sulphides. 17 tons 10 cwt. from 18 feet, mainly carbonate, yielded 15·5 per cent., and 5 tons 9 cwt., carbonates and sulphides, from 18 to 22 feet, yielded 27 per cent."

The ore having become pinched and poor with depth, aid was granted in 1903 (P.B. $\frac{82}{51}$) to sink from 112 to 162 feet, and to drive 50 feet at bottom.

The lode had at this time been sunk on 110 feet, and driven on north 70 feet at the 60-feet level and south for 60 feet. Stoping had been carried up for a length of about 70 feet.

Under the grant, sinking was only continued for about 10 feet when operations were suspended owing to water and low grade.

The mine was taken up again in 1906, work being resumed by J. Peel. About 100 tons of ore were raised in 1907, but not treated or despatched.

The total output of ore during operations amounted to 470 tons 4 cwt. 2 qrs. 13 lb., yielding 64 tons 19 cwt. 2 qrs. 19 lb. of copper—equal to 15·2 per cent.

Queen of England Claim.—On same lode, 400 feet from the main mine Shaft, 85 feet.

Molong Division.

Little Copper Hill Mine.—Three and three-quarter miles from Molong on the Wellington road, about half a mile from the old Copper Hill Mine, parish Copper Hill, county Wellington, on the Larras Lake Estate.

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LACHLAN MINING DISTRICT—*continued.*

Probably first opened when Copper Hill was in operation; reopened in October, 1906.

The copper occurs as carbonate and a little grey ore in soft, ochreous material, filling vugs or cavities in limestone. Very irregular in occurrence, not forming definite channels. Several shafts have been sunk by the present syndicate from 30 to 60 feet, most, if not all, down to solid limestone.

The ochreous lode material is extremely light, soft, and friable, nineteen large bags (not ore bags) going to the ton. The soft filling of the cavities containing the copper ores has evidently resulted from dissolution and removal of the limestone by acidulated waters, and precipitation of insoluble oxides.

The composition of the ochre is shown in the following partial analysis :—

No. 08-587—Ferric oxide	18·60	per cent.
Manganic oxide	18·00	,,
Copper	1·65	,,
Gold, a trace.		
Silver, 4 dwt. 14 grs.		per ton.

The mass of the small hill is limestone. On east and west of the cupriferous portion large segregated masses of quartz and quartzite occur. A highly altered igneous rock (probably andesitic) also occurs in close proximity.

The total output of ore despatched between October, 1906, and 16th December, 1907, according to the manager, Mr. W. T. Campbell, amounted to 195 tons 3 cwt. 2 qrs. 20 lb., averaging 13·81 per cent. of copper.

Fifield Division.

Mahgalore Lode.—Two miles from Wilmatha Tank, and 12 from Melrose, parish Parkes, county Cunningham. Strike N. 70° E.; dip slight S. 20° E. In felsite. Lode consists of ferruginous quartz, partly chalcedonic; iron oxide abundant. Copper carbonates occur on joint faces of felsite, near surface. At 50 feet, copper ore in gossan met, which continued to 75 feet, 3 feet wide.

Aided (P.B. $^{4}\frac{2}{0}\frac{2}{0}^{2}$) for sinking from 36 feet to 96 feet. Sulphides showing at the latter level. Aided to continue shaft to 185 feet. At 140 feet pyrites with a little copper sulphide reported. Water heavy. No further record.

Condobolin Division.

Melrose Copper and Silver Mine, about three-quarters of a mile west of the "Melrose Hotel."—Discovered and opened by J. Byrum, who was aided to sink from the Prospecting Vote. The mine is situated on a rugged hill about half a mile north of the Big Ben Mine. Ferruginous slate crops out in cliff-like masses on its summit, having a north and south cleavage. In one spot the slate was stained by copper carbonates, forming films on the cleavage planes. A few feet to the west a flat cross joint carried some massive carbonate of lead, stained with carbonate of copper. It has been followed some distance on the dip to the north-east. The aided vertical shaft is situated between the two outcrops, and a crosscut intersects the cupriferous slates at about 100 feet deep. At this level the cleavage planes of the unweathered slates are coated with films of red oxide, which accounts for the carbonates on the surface. Prospecting operations did not reveal a payable ore deposit.

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LACHLAN MINING DISTRICT—*continued*.

Melrose District.—Copper ores occur sparingly over a considerable area in this district, but so far none have been proved in workable quantity. Copper was first discovered hereabouts by J. Byrum about 1884. The chief feature of interest is the association of the copper ores chiefly with ancient conglomerates, much crushed and indurated. The pebbles consist of quartz, and the cementing argillaceous material has by pressure and shearing assumed a schistose structure. The alternating slates and sandstones are highly ferruginous. In some instances the cleavage planes of the slates are coated with copper carbonate, which, at a lower depth, gives place to a film of red oxide of copper.

From Mount Nobby three samples were assayed in the Departmental Laboratory in 1907—Nos. 5662-4—for yields of 7 to 14·75 per cent. of copper; gold, a trace to 2 dwt. 4 grs.; and silver, from 14 dwt. to 1 oz. 2 dwt. per ton.

Molong Division.

Molong Creek.—S. Stutchbury, in 1851, mentioned finding a green rock, "smaragdite," containing pure native copper, about 1 mile south of Mr. John Smith's house, and 100 yards west of Molong Creek.

In Spring Creek, near its junction with the Bell River, in the parish of Eurimbla, county Gordon, large pieces of native copper were found on the surface. A few thin quartz leaders, with calcite showing carbonates and grey sulphide of copper, and assaying 43 per cent. of copper, were sunk upon, but gave out at a shallow depth, according to W. Anderson (Ann. Rept., 1888, p. 183).

Fifield Division.

Mordialloc Copper Mine.—On Mordialloc Station, 3 miles from Trundle, parish Plevna, county Cunningham Strike N. 70° E.; dip north 10° west at about 9°.

Mr. F. Danvers Power reports that two other lodes on the north have also been prospected. Lodes associated with decomposed andesitic rock. Average channels 4 feet wide, but not all ore-bearing. The productive parts form small lenses. Carbonates above water-level, sulphides below; associated with quartz. Grey ore in north blocks.

South lode developed by three shafts and some trenches for about 4 chains. Carbonate stains noticeable in the material thrown out.

Western and middle shafts old and inaccessible. Recent work confined to eastern shaft. At 47 feet a level has been driven easterly for 27 feet and west 5 feet from the shaft. A sample from 2 ft. 10" in. wide yielded 2·4 per cent. of copper, with traces only of gold and silver.

Geological-Surveyor L. F. Harper reported (15/10/05) that D. Cheshire and party's lode was sunk on 80 feet and driven east 30 feet at the 60 feet level, and west 80 feet. Sulphides in bottom of shaft. One and a half tons yielded 9 per cent. of copper at Lithgow, 3½ dwt. of gold, and 3 oz. of silver per ton. Average width of formation, 3 to 4 feet.

Cootamundra Division.

Mount Felstead Copper and Silver Mine.—Portion 253, parish Yeo Yeo, county Bland, close to Stockinbingal-road, about 7 miles north-westerly from Cootamundra.

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LACHLAN MINING DISTRICT—*continued*.

Country quartz-felsite, in parts much crushed. Quartz veins and ferruginous jointings numerous, some containing a little gold but not payable. Discovered by G. E. Felstead.

Outcrop betrays no indication of the economic metals other than gold, which began to show at 36 feet. Three shafts (1903), 25, 52, and 70 feet. Payable ore struck in latter at 36, and penetrated 35 feet. Horizontal extension not tested; apparently a short lens.

The Mount Felstead lode appears to have originated from metallic and silicious solutions investing a jumbled mass of rock fragments resulting from shattered fissuring of the country at this point. The ore lens increased in width from 1 to 6 feet, about one-fourth of which is ore. The proportion, however, is variable owing to large blocks of country occasionally curtailing area of deposition.

The metallic ores consist of a mixture of carbonates, red and black oxide, and yellow sulphide, of copper; carbonate and sulphide of lead, and sulphide of zinc.

The composition of the mixed ores is indicated by the following returns of the first parcels despatched:—8 tons 3 cwt. 3 qrs. 6 lb. yielded, copper—13·9 per cent.; lead, 11·8 per cent.; silver, 49 oz. 11 dwt. 4 grs.; gold, 1 dwt. 14 grs. per ton. 7 tons 7 cwt. 3 qrs. 20 lb. yielded—copper, 11·5 per cent.; silver, 48 oz. 10 dwt. 19 grs. per ton.

Seventy tons of ore were raised and 50 sold, netting £150, in 1903. Shaft deepened to 80 feet. Driven 30 feet south, and 8 feet north. (Ann. Rept., 1903, p. 48.)

Re-opened in 1905, under name of Coolamundra Silver and Copper Mine. Main shaft deepened to 145 feet. Steam pump installed. 10 tons of ore despatched; 20 tons at grass. (*Ibid.*, 1905, p. 45.)

Under suspension for greater part of 1906.

During 1907, two winzes sunk from 70-feet level; main shaft deepened to 190 feet; 120 feet of cross-cutting and driving; 85 tons of ore sent to Swansea for treatment.

Cudal Division.

Mt. Keenan (*Amaroo Mine*).—Portions 252 and 255, parish Boree Nyrang, county Ashburnham; 1½ miles south of Amaroo Railway Station. Labradorite porphyry country. Formation described by Inspector G. Smith (P.B. $\frac{4}{0}\frac{4}{7}\frac{4}{4}$) as apparently 12 to 15 inches thick, showing copper carbonates freely.

Aided to sink to 60-feet level. The copper veins exposed near surface were reported to have dipped east out of shaft at 30 feet.

The output to date 8 or 9 tons, yielding 2 to 4 per cent. of copper; and 1½ tons, yielding 8·5 per cent. Deepest shaft, 90 feet; ore very thin at bottom.

Condobolin Division.

Mount Susannah Copper Lode.—About 1 mile from Melrose Homestead. A cupriferous outcrop in crushed conglomerate close to intrusive porphyry was opened here about twenty-four years ago by J. Byrum. Shafts sunk 30 and 40 feet revealed carbonate of copper impregnating the country for about 6 or 7 feet in width along a north and south strike, but no payable ore bodies were exposed. Aid was granted to continue one of the shafts to 100-feet level, and to drive along the lode.

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LACHLAN MINING DISTRICT—*continued.*

(COBAR MINING DISTRICT.—*Nymagee Division.**)

Nangeribone.—The following results have been obtained from samples from J. Brien's aided prospecting shaft :—

No. of Assay.	Description of Sample.	Copper, per cent.	Gold, per ton.	Silver, per ton.		
				oz.	dwt.	grs.
07–4705 ...	Slightly pyritic rock	2·60	a trace.	7	12	10
07–4706 ...	Ferruginous quartz with carbonates ...	6·30	,,	9	13	19
07–4707 ...	Pyritous quartz with carbonates and oxides.	7·17	,,	9	18	4

LACHLAN MINING DISTRICT.

Cudal Divison.

Nangar Range.—Copper ore in small quantity, so far as proved, occurs in two places on the north side of the Nangar Range, about 2 miles southerly from the "Murga Hotel." In Clayton's gold lease, at a depth of 80 feet, in ferruginous quartzite, a small patch of red oxide of copper was cut, but it appeared entirely isolated, as further search failed to reveal any other indications of a copper deposit. This occurrence is close to intrusive quartz felsite. About half a mile distant from this site, and close under the mural cliffs of the range, a little carbonate and sulphide of copper, associated with quartz and talcose material, has been opened for a few feet. The Nangar Range consists of massive conglomerates and sandstones probably of Devonian age.

Cowra Division.

Neila Creek.—In Conditional Purchase 78/75, parish Morongla, county Forbes, about 10 miles south of Cowra, a shaft has been sunk 73 feet in a strong gossan outcrop, in which a little copper is visible. A crosscut has been driven 108 feet. Aid was granted to continue sinking.

Parkes Division.

Parkes District.—Copper ores occur in small quantities in numerous localities in this district. The following have been noted :—

Goobang Station, 5 miles north-west of Parkes.—Copper ore discovered in 1882, and a few tons raised.

Gobandry, 8 miles north-west of homestead.—Copper ore prospected about thirty years ago to 50 feet. Traces only exposed.

Goonumbla Hill, 13 miles north-west of Parkes, on Goonumbla-road, also 4 miles S.S.W. of Goonumbla Hill, on the main range.—Copper ores occur.

Limestone Reserve, 6 miles north-west of Parkes.—In 1883 a shaft was sunk 110 feet in a lode striking north-east and south-west. Twelve tons of ore raised.

Gunningbland Station, 18 miles west of Parkes.—A strong outcrop of ironstone, carrying copper carbonates and galena, occurs here, which was partly opened under prospecting aid in 1898, but unsuccessfully.

Little Mount Currumbla Station, 12 miles west of Parkes.—Native copper occurs here in andesite with quartz and epidote.

Langford's Lease, 12 miles north of Parkes.—Lode traced on surface for about 190 yards by cuttings and trenches, the deepest 18 feet. Lode about 1 foot thick. Assays of samples returned 7 to 30 per cent. of copper.

* Should appear on page 254.

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About 1½ miles east, and also west of this lease, copper indications also occur.

Welcome Reef.—Close to this reef, about 2 miles from Parkes, on the Forbes line, Mr. J. Stott reported copper ore. Opened out some years since to a shallow depth.

Trundle.—Four miles south-east and the same distance north-east in the same belt of slate, copper indications occur—in one instance native copper—but nothing payable known, aid was granted one site from the Prospecting Vote.

Cumnock.—Five miles west on Peak Hill and Dilga-road, a patchy copper vein was opened thirty-five years ago to a depth of 30 feet. Taken up again about 1890. Nothing payable or permanent discovered.

Molong Division.

Peabody Copper Mine.—Six miles southerly from Molong, close to the Cudal-road. In J. Black's private land, parish Boree Nyrang, county Ashburnham. Rich bunches of copper ore at surface. Opened by J. Torpy and others about 1872. Copper ores from this mine were exhibited at the Philadelphia Exhibition in 1875.

The prospectors sank two shafts 60 and 100 feet. The following extracts are from a report dated 27th July, 1872, by Captain Reynolds (manager of the Icely Mine, at that date), supplied by J. W. Torpy:—

"Rich veins of red oxide cut at 9 feet and followed down to lowest point reached. Trend north and south. Red oxide and malleable copper broken from shaft. In two places, 50 yards south of main shaft, several rich veins of same class of ore were being uncovered. Outcrop, inconspicuous."

Captain White (of Carangara Mine) at same date described width of lode as 3 to 5 feet. Underlay west at 1 in 6. Traced for about 160 feet by shafts and open cuts.

In 1900, F. Danvers Power described the occurrence of native copper, cuprite, and carbonates in joints of andesite, more especially near the walls of this rock.

Assays of samples of the ore lying at grass yielded—copper, 6 to 9 per cent.; silver, 10 to 17½ dwt., and gold, a trace, per ton.

Condobolin Division.

Phœnix Mine (formerly Shepherd's), G.Ls. 10 and 277, parish Condobolin, county Cunningham, about 2½ miles north of Condobolin.—During 1906 120 tons of ore were reported to have been raised and despatched for a return of £466. (Ann. Rept. 1906, p. 47.)

In 1907 Inspector G. Smith reported the minerals present as gold, silver, and copper, in schist; worked chiefly for gold. Depth of proving, 210 feet.; length, 90 feet. Mine idle.

Six tons of copper ore yielded 5 per cent., and 17 dwt. of gold and 7 oz. of silver per ton. Thirteen hundredweight of lead ore yielded 25 per cent. lead, 17½ dwt. of gold, and 19 oz. of silver.

Molong Division.

Pine Hill Copper Lode, M.L. 1, parish Gumble, county Ashburnham, 13 miles from Molong Railway Station, and 10 from Manildra.

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LACHLAN MINING DISTRICT—*continued*.

F. Danvers Power reports a contact lode between granite and limestone, developing garnet. The copper occurs in the latter chiefly as carbonate, with sulphides below water-level.

Shaft sunk about 1880 to 55 feet on hanging wall, but did not cut lode. Copper-bearing portion of garnet apparently 6 to 8 feet wide, but not of uniform richness. Copper stains extend beyond limits mentioned.

First shaft to north sunk in 1903, on underlie to about 20 feet. Next, or middle shaft, sunk 60 feet, part vertical, part underlie. Usual grade of ore. No workings.

North shaft, 120 feet deep, part vertical, part underlie. Crosscut at 80 feet, showing a width of 12 feet of copper-bearing garnet. A short drive to south at bottom of shaft revealed a good deal of magnetite. Crosscut west into limestone. Strike of deposit about N. and S., underlie 60° to West. Most development at southern end. A sample from 8 feet across the third trench, near southern end of block, yielded 2·7 per cent. copper. Sample from heap of selected ore from neighbouring trench, picked as clean as possible, averaged 2·9 per cent. copper, and a trace of gold. Green garnet imparts a deceptive appearance of copper value.

From east crosscut at bottom of northern shaft, a sample from a width of 5 feet assayed 2·28 per cent. copper. Copper contents appear fairly constant, and naturally richer than to be expected below.

Condobolin Division.

Ramping Lion Lode, 2 miles north of Condobolin, parish Condobolin, county Cunningham.—Inspector J. James reported (P.B. $\frac{21}{3}\frac{1}{4}\frac{8}{4}$) a vein 12 to 20 inches wide in schist, good ore being obtained in two shafts to 25 feet. Aided to sink from 25 feet to 100 feet. At 33 feet copper stains; at 50 feet, slate and ironstone; at 75 feet, no ore.

Molong Division.

Reedy Creek.—On the 12th April, 1852, S. Stutchbury reported: "At 300 yards from Reedy Creek, and half a mile from the station hut, which bears E. 10° S., is a mound of porphyry, composed of a red paste with crystals of felspar, traversed by veins of prehnite. Masses of ore have been found with native copper, several large lumps of which have been found. One, weighing 102 lb., is now in the possession of Mr. Smith." Probably this lump is identical with the exhibit at the London Exhibition of 1851, consisting of 1 cwt. of native copper from Reedy Spring, the property of the late Mr. Smith, of Gamboola Station, near Molong. A similar block, weighing $\frac{3}{4}$ cwt., from the same locality, is at the station homestead.

Gundagai Division.

Reno, about 3 miles south J. Robinson's private land.—Inspector E. C. Whittell reported (P.B. $\frac{21}{0}\frac{8}{0}\frac{4}{0}$): "Copper-bearing quartz vein in slate, carrying 1 to 4 inches of yellow copper ore." Aided to sink to 65 feet.

Condobolin Division.

Rifle Butt Claim, 3 miles N.W. of Condobolin, parish Condobolin, county Cunningham.—Inspector Smith reported (P.B. $\frac{21}{0}\frac{2}{7}\frac{0}{0}$): "A small vein of copper ore of good quality (15 to 20 per cent.), but too small for profitable working. Bismuth also present." Aided to sink to 100 feet.

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LACHLAN MINING DISTRICT—*continued.*

Junee Division.

Rockdale Gold and Copper Mine.—P.G.L. 1, parish Warri Warral, county Clarendon, Junee Reefs.—Baker and party reported that in sinking their main shaft, at a depth of 60 or 70 feet, a band of blue and green carbonates of copper was struck, having an average width of 1 ft. 6 in. This ore continued in the shaft for about 8 feet with a northerly dip. At 100 feet, the reef consists of ferruginous quartz, stained with copper carbonates. Samples of the blue carbonates assayed 24·96 per cent., and the green about 12 per cent. In the former, a return of 6 oz. 9 dwt. of silver was also obtained. From this mine it was also reported that samples of the auriferous portions of the reef treated at Wyalong, Footscray, and Ballarat (Victoria), yielded from 3 to 7 oz. of gold per ton. Ordinary battery treatment reported unsuitable for extraction.

Condobolin Division.

Sultan Copper and Lead Mine, portion 1, parish Condobolin, county Cunningham.—Discovered by B. Roberts, about 1876. Three miles N.W. of Condobolin. Inspector G. Smith reported (29/10/06) copper ores in schist. Worked to 90 feet, stopes filled. Said to have been 2 feet thick. New shaft 18 feet.

During previous five months 17 tons 17 cwt. despatched yielded about 13 per cent. of copper, 14 oz. of silver, and 1 dwt. of gold per ton.

Two previous parcels treated at Dapto during the previous year yielded: 7 tons, 11 per cent.; 10 tons, 17 per cent.

T. W. Copper Lode (late Byrum and Sinclair's), portion 9, parish Melrose, county Cunningham, 31 miles from Condobolin Railway Station.—Discovered by James Byrum in 1882. Ores: copper, lead, and silver. No output. Prospecting company formed. Old shaft 45 feet sunk under aid.

Described by Inspector G. Smith (3/11/06) as impregnated schist. Strike N. 20 W.; dip N.; 70 E., shaft, 67 feet.

Cudal Division.

United Empire Mine, 2½ miles east of Murga, and 17 miles from Moura Railway Station.—Inspector G. Smith reported (P.B. $\frac{A\,4\,3\,A}{0\,7}$): "A strong quartz vein in quartz-porphyry, said to average from 4 to 6 feet wide. Copper carbonates and sulphate showing freely, and a little copper pyrites in lower portion of shaft."

Aided to sink from 100 to 150 feet, and to drive 100 feet on vein at bottom. Originally worked for gold.

Canowindra Division.

Vychan Copper Mine, portion 81, parish Wise, county Ashburnham, 20 miles east of Forbes, 8 miles from the Lachlan River, and 14 miles from Cookamidgera Railway Station.—Copper was discovered in the adjoining Eurow Mine—300 feet distant—by a member of D. Sloan's family, about 1881. The site was secured by mineral conditional purchase, but was abandoned after three shafts had been sunk. In 1889, 56 tons 9 cwt. from this lode, forwarded by Mr. A. Lockart to the English and Australian Smelting Works, Waratah, yielded 17⅛ per cent. of copper.

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The country consists of highly-crushed and altered rocks. The lode strikes N. 30° W., and dips west.

The Vychan Mine was taken up by F. Clayton as a mineral lease of 40 acres in September, 1897. The main shaft was continued to the 150-feet level, and the north to 120 feet. Levels connect the shafts at 30, 109, and 150 feet. The sulphide ores began to appear at about 120 feet from surface. Above this level oxidised ores occurred in bunches. The lode varied from 1 to 8 feet in thickness, averaging about 2 feet. Both the oxidised and sulphide ores were of excellent quality. To 1899, about 50 tons of ore had been despatched to the Smelting Company of Australia, Limited, Dapto, the copper contents of which ranged from 17·7 to 25·3 per cent; silver, from 4 to 10 oz.; and gold, 2 to 5 dwt. 14 grs. per ton.

Since the date mentioned, the following consignments were treated at the above works for yields shown in the accompanying table, which reveal the character of the ores:—

Weight.	Copper.	Silica.	Gold, per ton.	Silver, per ton.	Nature of the Ore.
	per cent.	per cent.	dwt. gr.	oz. dwt. gr.	
53 bags (?)	20·5	20·2	1 19	3 2 9	1st carbonates.
22 ,, (?)	12·5	20·6	4 14	1 19 14	2nd ,,
10 ,, (?)	12·4	26·8	4 4	2 3 14	2nd ,,
tons cwt.					
4 17	21·7	.....	3 0	.....	1st ,,
1 1	16·1	.....	3 4	.....	2nd ,, (screenings).
2 16	16·3	.....	1 19	.....	Fines ,, ,,
2 4	23·3	.....	4 0	.....	1st ,,
5 10	8·5	.....	3 19	.....	4th ,,
6 17	9·6	.....	2 14	.....	Sulphides from 150-foot level.
2 6	23·9	.....	2 4	.....	Carbonates.
1 7	17·5	.....	2 19	.....	Fines ,,
8 5	11·0	.....	2 14	.....	Sulphides.
6 0	13·0	.....	3 0	.....	1st sulphides.

In driving between the north and south shafts at the 150-feet level, the main body of sulphides was struck near the north shaft, at an angle which carried it about 7 feet west of the south shaft, from which the level started, and accounted for the blank country in the latter. The sulphides were solid and 6 feet wide at the point of intersection.

Prospecting northerly from the 120-feet level in the north shaft. After 50 feet of blank country, copper stains and a little copper glance made in the drive. (For particulars of the adjoining mine, on the same lode, *see* Eurow Mine.)

Worked for five months in 1901, value of output, £720—ore averaging 15 to 19 per cent. (Ann. Rept. 1901, p. 55.)

Worked on tribute in 1902—ore 18 to 22 per cent. Lode irregular; in bunches.

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MUDGEE MINING DISTRICT.

Dandaloo Division.

Ace Mine, M.Ls. 24 and 31, parish Beaconsfield, county Kennedy.—Lode outcrops for about 350 yards in bunches of porous iron oxide after pyrites. Strike N. 30° W.; dip N. 60° E., varies from 45° near surface, to 32°, and then 35° at 250 feet.

The main—or underlay—shaft has been sunk 321 feet, water being struck at 275 feet.

Development.—Lode driven on 25–30 feet at the 170-feet level, 140 feet at the 220-feet level, and 80 feet at the 270-feet level. From the latter a crosscut has been driven 240 feet north-easterly to connect with No. 2 (vertical) shaft.

The ores consist of oxides, carbonates, and grey ore at 170-feet level; native copper and enriched sulphides at 220-feet level. At 270 feet, enriched sulphide (black) and pyrites occur south of shaft, also making north. The width of channel at each level being 4 feet, 6 inches to 6 feet, and 3 to 5 feet respectively.

At 321 feet the owner (Mr. A. H. Dight) reports about 1 ft. 6 in. of lode-stuff, carrying 6 inches to 8 inches of good ore, the remainder being pyrites.

No ore has been despatched, the work carried on being purely developmental; a smelter being contemplated when a safe margin of ore is in sight.

It is estimated by the owner that on the 10th January, 1908, there were in hand about 40 tons of firsts and 150 tons of seconds. The gossan is also estimated by him to contain from 1 to 2½ per cent. of copper, and the pyrites 1½ per cent.

A sample of the massive sulphides at 220 feet, taken by the Writer, yielded the following results:—

No. 07-2374	Copper	5·42 per cent.
	Iron	36·26 „
	Sulphur	24·60 „
	Silica	6·98 „
	Gold	a trace per ton.
	Silver	16 dwt. 8 grs. per ton.

A sample of the screenings from 250-feet level yielded:—

No. 07-2373	Copper	3·10 per cent.
	Iron	37·94 „
	Sulphur	39·52 „
	Silica	10·02 „
	Gold	a trace per ton.
	Silver	17 dwt. 10 grs. per ton.

The composition of the sulphides in this mine (also those of Mount Royal, Orange Plains, and Bogan River mines, so far as proved), illustrated in partial analyses, reveals most kindly smelting ore, the low silica rendering it eminently suitable for fluxing the silicious surface ores of the district.

Wellington Division.

Backes' Copper Mine.—Leases for copper were taken up about 1873 by John Backes, at Sugarloaf, parish Galwadgery, east of Wellington. In 1883, the Warden described the mine as situated east of The Springs Railway

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Station, near the Burrandong-road. At this time it was designated the Great Burril Mining Company's Lease. One of the proprietors, C. Barton, supplied the Warden with the following information:—Three shafts, over 100 feet each, have been sunk, also a number of shallower ones. The first shaft was on a vein rather inconstant in thickness, sometimes pinching out, the maximum thickness being 2 feet; about 25 tons of ore were taken from it, averaging about 12 per cent. copper. Another shaft, sunk at the north end of a large gossan outcrop, reached a deposit of copper and iron pyrites. A drive to the eastward, at 60 feet, discovered a small quantity of decomposed lodestuff, containing native copper. Assays of ore then at grass were reported to yield 8 to 14 oz. of silver per ton, and from 4 to 7 per cent. of copper. The principal feature of the property was reported to be an immense gossan "blow," or outcrop.

Gulgong Division.

Belara Copper Mine, about 25 miles from the Wellington Railway Station, alongside the main Mudgee road. Locality also known as Goolma. Portions 27, and 31 (100 acres), parish Worobil, county Bligh.

The Belara Mine, according to the Warden's report of 1880, p. 98, was discovered by G. McDonald on freehold land. In the "Mineral Statistics of New South Wales," 1875, p. 90, the lode is recorded as 2 feet thick. Strike N. and S.; dip 1 in 3. One hundred and fifty tons of ore were then at grass, but no tests had been made.

The next official record is that of the Under Secretary for Mines in 1885, in which it is stated that 1,000 tons of ore had been raised during the year, producing 640 (?) tons of regulus, which is evidently an error. Depth of shaft, 160 feet; deepest level, 140 feet. Width of lode, 8 inches to 8 feet.

In 1886 there was no record; in 1887, 100 tons of ore were raised, but no smelting was done; during 1888, 1,400 tons of ore were raised, 840 of which were smelted for 70 tons of copper, valued at £5,250.

In 1889 little work was done. Three hundred tons of ore raised yielded 16 tons of copper, valued at £800. The smelting furnaces were only worked for three months, mostly experimenting with gossany gold and silver ores.

In 1890 the only work performed was the deepening of the engine shaft to 55 feet. The mine apparently remained idle from this date until October, 1893, when twenty men were employed until May, 1894. Two hundred tons of ore raised during this period yielded 9 tons of copper. So far as official returns are recorded from this mine, the output amounted to about 260 tons of copper to the end of 1907.

D. H. Thomas and others had the mine on tribute in 1893 for about six months, during which about 20 tons of copper were produced (9 in the official return). To Mr. Thomas the Writer is indebted for the following particulars, which represent the mine as it then stood:—Shaft, 200 feet deep; levels at 112 feet and 155 feet (lowest); lode, 3 feet wide at 112 feet, 6 feet at 155 feet. Value of ore—5 per cent. copper; gold, 3 dwt., and silver, 3 oz., per ton. The lode traceable on the surface for a considerable distance by a gossan cap from 1 ft. 6 in. to 12 feet wide, in which gold and silver are

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E. R. Cocks. **Belara Smelting Works.**

E. R. Cocks. **Belara Copper Mine.**

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PLAN AND SECTIONS OF THE BELARA COPPER MINE

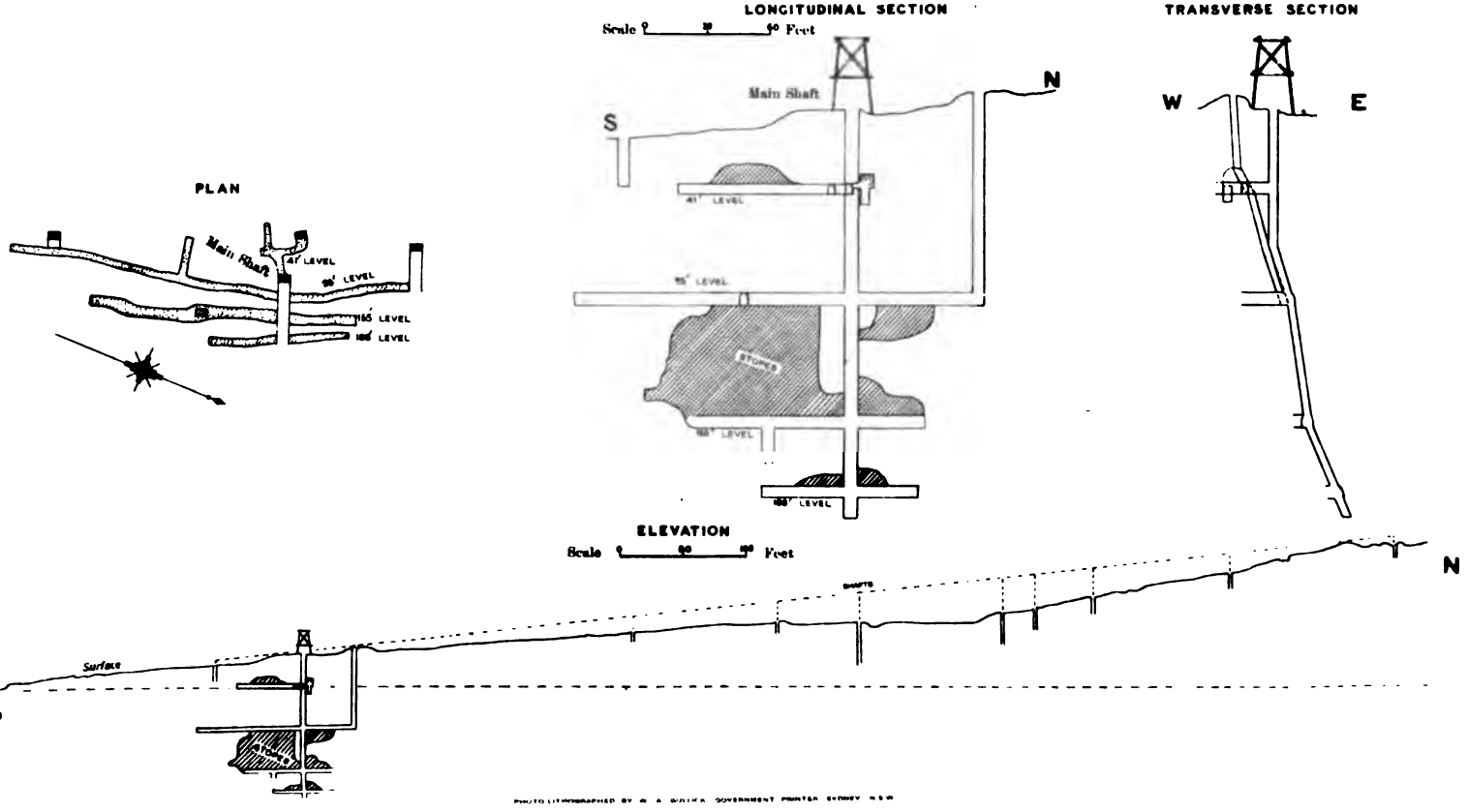

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PHOTO-LITHOGRAPHED BY W. A. GULLICK, GOVERNMENT PRINTER, SYDNEY, N.S.W.

present. Carbonates of copper showing in lode 300 yards north of shaft. Gangue silicious at surface. Sulphides from lowest level solid. Country consists of slate.

The smelting plant at this time consisted of two reducing, one calcining, and one refining furnace. Firebrick made from clay, obtained about 9 miles distant.

The Belara Mine was examined by the Writer in December, 1907, and January, 1908. The lode strikes about N. 20° W. in slate country, about 90 feet west of an intrusive dyke of quartz-felsite, to the occurrence of which it doubtless owes its origin.

The channel, in which the ore makes in lenses, is persistent for a considerable distance, as shown in the accompanying longitudinal section of Belara provings supplied by Messrs. Cock Bros.

The Native Bee Mine, recently discovered, about 80 chains southerly, is also on the same strike.

The Belara section has been superficially proved by shafts and shallow openings for about 1,540 feet northerly from the main shaft, and about 120 southerly. Though these shafts are not now available for inspection, it is evident that ore has been raised from them. At the extreme north end, ore has evidently been removed from an open excavation where two outcrops of gossany lodestuff occur, separated by a horse of country in part igneous. These superficial workings probably afforded oxidised ore for fluxing during early smelting operations. It is highly probable that lenses of sulphides occur beneath.

The width of ore exposed in the main shaft varies from a few inches at the pinched northern end of the lens up to 10 or 12 feet. The lens averages from 3 feet to 8 or 10 feet in width.

At 100 feet pyrites occurs massive but poor in copper, zinc-blende also being prominent. At the lower levels the latter averages about 4 or 5 per cent, in places, however, making solid on the hanging wall up to a foot in thickness and to 40 per cent. metallic zinc. This band was usually discarded in working.

Recent developments.—Leased to Captain H. Cock in 1899, under a purchasing option. Main shaft unwatered, depth 200 feet. Opened out at 150-feet level, and stoped up to 100-feet level on south side of shaft, for a length of about 70 feet.

Seven hundred and eighty tons of ore (including some from surface) smelted for 36 tons of copper, equal to an extraction of 4·6 per cent. The copper product contained gold to the value of £9, and silver £7, per ton.

Operations ceased after two years' continuance, not proving remunerative with the plant available.

In March, 1907, the same shaft was unwatered and repaired by Messrs. Cock Bros.; and the lode driven on 25 feet each way at the 200-feet level; and underhand stoped 60 feet long and 12 feet deep on south side of shaft.

During operations—which ceased in December, 1907—807 tons of ore were treated in the local reverberatories for an average return of 3·33 per cent. of copper; and gold at the rate of 1·47 dwt., and silver 2·21 oz., per ton.

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Solid ore remains between the 200 and 150-feet level stopes. The south face at the former level at present reveals 3 to 5 feet of sulphide ore, zinc-blende making on the hanging wall. An average sample from a width of 3 ft. 6 in. in face yielded the following composition:—

No. 08–160	Copper	2·40 per cent.
	Iron	34·25 „
	Zinc	11·34 „
	Sulphur	48·28 „
	Silica	28·48 „
	Gold	2 dwt. 4 grs. per ton.
	Silver	2 oz. 18 dwt. 19 grs. per ton.

From the south face at 150-feet level the following average sample was taken from a width of about 7 feet:—

No. 08–161	Copper	1·20 per cent.
	Iron	22·12 „
	Zinc	19·74 „
	Sulphur	29·49 „
	Silica	10·60 „
	Gold	2 dwt. 4 grs. per ton.
	Silver	2 oz. 18 dwt. 19 grs. per ton.

The local smelting plant consists of two reducing and one roasting and refining reverberatories. The sulphide ore was roasted in clamps—reduced to 12 per cent. matte in first, and 40 per cent. matte in second smelt; in which form it was recently despatched. This ore is described by Mr. E. R. Cock as free-smelting and self-fluxing; and would be most suitable for blast furnace treatment.

The shallow development—200 feet—in one site only, cannot be regarded as an efficient test of the possibilities of the Belara lode. It is highly probable that other lenses will be proved below the shallow oxidised zone on the northern strike. Development of other sulphide bodies on the course of the lode, even of the moderate grade exposed in the main shaft, should give a new life to the mine under blast furnace treatment, and lead to further discoveries along the strike towards the Native Bee Mine.

Dandaloo Division.

Bogan River Copper Mine (formerly Royal Sweep), M.L. 1, parish Beaconsfield, county Kennedy.—About 20 miles from Dandaloo, on the Bogan River, and 48 miles from Trangie Railway Station. The Bogan Gate–Bulbodney Railway, however, has been surveyed within 8 miles.

Discovered by W. Shallalla in 1905. Supposed to be on faulted continuation of Mount Royal lode about half a mile distant; connection not proved.

Work under Bogan River Company began in February, 1906.

Strike of lode, N. 62° W.; dip S. 28° W. at 47°. Width from 1 foot to 3 feet, in places 4 feet or more. Opened by three shafts, 65 feet, 100 feet, and 150 feet. At 60-feet level 150 feet driven on ore, and 65 feet at 140 feet, when examined, August, 1907. Sulphides at 150-feet level of low grade.

Strike of lode N. 62° W.; dip S. 28° W. at 47°. Width 1 ft. 6 in. to 4 feet.

Country—micaceous schist. Outcrop ill-defined.

The following particulars of subsequent developments to 19th May, 1908, have been supplied by the manager, Mr. D. Jones:—

"Depth of shaft, 125 feet; a level driven at 60 feet, and one at 120 feet; length of No. 1 level, 340 feet; stoping in oxidised ore from 18 inches to 6 feet in width; value 9 per cent.

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MUDGEE MINING DISTRICT—*continued.*

"No. 2 level driven 324 feet in decomposing sulphide the whole distance, varying in width from 2 feet to 12 feet; average value, 5 per cent.

"Poppet legs and winding engine have been erected; also 600 feet overhead tramway from shaft to furnace and burning floors, respectively.

"Preparatory to smelting, the sulphides are roasted in heaps; and, after roasting, are practically self-fluxing.

"Ore raised to date, approximately, 2,500 tons, representing the amount mined from No. 1 level and stopes therein, and from drive at No. 2 level; no stoping yet done at No. 2 level.

"Generally speaking, the lode seems of a permanent character, as ore is showing underfoot in the whole length of No. 2 level.

"Ore disposed of as follows:—

Sold	627	tons firsts.
„	80	„ seconds.
Smelted	560	„ all classes.
On surface	1,000	„ „

"From the 560 tons smelted, 28 tons blister copper have been obtained.

"(1) Reverberatory furnace—Dimensions of hearth 23 feet x 12 feet, underground culvert 50 feet, to stack 60 feet high.

"Smelting commenced in February (1908), and is proceeding satisfactorily, taking the present price of copper into consideration.

"There is an abundance of wood for furnace fuel close at hand.

"Two tanks have been excavated by the Company of a capacity of 5,000 and 1,000 yards respectively."

Wellington Division.

Bungiebomar (or Copper Hill) *Mine.*—J. Crick's land, parish Bungiebomar, county Lincoln, about 25 miles from Wellington.

Mr. F. Danvers Power informs the Writer that copper carbonates occur here in joints of andesite, with cuprite and native copper in small irregular bodies, not along any defined lines. Best show of the kind in Smith and Stewart's shaft, where carbonates are exposed for its length and breadth to the lowest level. Occurrence similar to Delaney's Dyke near Molong; but it does not offer much inducement for development.

Leadville Division.

Bowenbang Creek, 4 miles from Hannah's Bridge, Leadville to Coolah Road.—Dawson's prospecting shafts, 40 feet and 70 feet, sunk on different veins in which rich grey copper ore occurs in prills up to 40 per cent. grade, but not in quantity.

Dandaloo Division.

Christmas Gift Mine, Albert Water Holes, M.L. 1, parish Albert, county Kennedy, 13 miles from Dandaloo, 43 miles from Trangie Railway Station, and about 7 miles from Bulbodney line, in course of construction.—Discovered by C. J. Keenan, Christmas, 1897. Strike N. 75° E.; dip S. 15° E. to 60° in contorted schist. Position in March, 1907: Opened to 233 feet in depth, driven 13 feet south-westerly, stoped where payable upwards for a

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length of 100 feet or more in oxidised ores. Probably 200 tons of ore despatched. Discoverer sending 96 tons of a reported yield of 13 to 36 per cent. of copper.

Work stopped for some time. Two men now raising ore on tribute. A few bunches left in higher levels.

Silicious sulphides at 233 feet, good grade when dressed. Lode about 2 feet wide at this level.

Two parcels despatched in June, 1907, reported to have yielded—carbonates, 26 per cent.; sulphides, 10 per cent. Quantities not stated.

Chris. Watson Mine, M.L. 16, parish Beaconsfield, county Kennedy—Adjoining Mount Royal Mine on east end. No outcrop. Small bunch of ore cut in drive from 80-feet level in shaft. Eight tons yielded 18·5 per cent. copper.

In February, 1908, 22 tons of ore from this mine are reported to have assayed 23 per cent. copper.

Leadville Division.

Denison Town, Talbragar River.—In 1888 a copper lode in slate country was opened by Messrs. Wall and Lynch during the copper boom of that year, near the south-west boundary of Pine Ridge Station. Outcrop traceable for about 20 chains, but very narrow, striking about north and south. Opened to about 18 feet. Twenty-eight tons of carbonate and grey ore sent to the Waratah Smelting Works reported to have yielded nearly 15 per cent. copper. The site has recently been taken up by Mason and others, of Leadville. (*See* Mount Laut.)

Wellington Division.

Dripstone.—The Blayney Mining and Smelting Company in March, 1908, secured an option over a copper lode on the Camelford Park Estate, near Dripstone, and a start was made to prospect it.

Great Wheal Burril Consols Copper Mine, Burril Ranges, 9 miles from Wellington.—This property formed the subject of a dispute brought before Parliament in 1873. The matter being disputed mineral selections by Burns, Philp, & Co., embracing Mylecharane's Lode, Muddy Creek, on Burril or Booral Run. Copper ores in the Australian Museum, purporting to have come from a depth of 45 feet in a 30-feet lode, are labelled with this name, but nothing authentic is known of the deposit. (*See* also Backe's Mine.)

Gulgong Division.

Gulgong.—Within 3 miles of Gulgong (probably Isbester's Paddock, 3 miles east, where a broken lode was opened to 70 or 80 feet). Copper ores were sent for assay in 1895, Nos. 2531–2 yielding from 25 to 32·67 per cent. of copper, and 13 oz. 12 dwt. 4 grs. of silver per ton. In 1896 a sample purporting to come from a hill near the Canadian Lead, No. $\frac{2}{3}\frac{4}{5}\frac{0}{6}\frac{2}{7}$, yielded 35·67 per cent. of copper, and 3 oz. 11 dwt. 20 grs. of silver per ton. Shaft sunk 40 feet. Fifteen hundredweight yielded 22 per cent. of copper at Waratah. (*See* Invicta Mine.)

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Mudgee Mining District—*continued.*

Dandaloo Division.

***Honeybugle*, about 16 miles west of the Bogan River at Dandaloo.**—Geological Surveyor Young (Ann. Rept., 1880, p. 262) recorded the occurrence of a quartz reef stained with carbonates of copper in hornblende porphyry, at Honeybugle. Thickness of reef, about 14 inches; strike, N. 6° W.; dip, slight, to the W. Since that date a shaft was sunk about 80 feet, the country being hard and the reef small. Gold is present in the veinstone.

Gulgong Division.

***Invicta Gold and Copper Mine*, 3 miles easterly from Gulgong.**—Copper and gold here occur in an altered igneous rock. The following samples have been tested:—

Carbonate ore ...	No. 07-661—Copper	39·25
	No. 07-662—Copper	31·55
	No. 07-663—Copper	37·60

Five tons raised during 1907 disposed of for £96.

Reported to be of irregular occurrence and not persistent.

Dandaloo Division.

***Iron Duke Lode*, Albert Water Holes, M.L. 2, parish Tabratong, county Kennedy.**—Opened by C. J. Keenan about 1899, to a depth of 25 feet, and crosscut 30 feet.

A strong silicious outcrop, with stains of copper carbonates visible in the enclosing schist.

Strike N. 35° E.

Being developed in 1907 by the Iron Duke Copper-mining Co., Limited.

Wellington Division.

***Kaiser Mine*, 11 miles by road from Wellington, and 3 from Bodangora.**—Worked for gold for widths varying from 9 to 20 feet, and to a depth of 60 feet at different points, for a length of about 500 feet. Costeens further proving the outcrop for another 100 feet.

Copper carbonates manifest below the first outcrop, and sulphides at the lowest levels attained.

The Writer is indebted to Mr. J. Carey for the following notes from his systematic sampling tests, recently made:—

"From an open cut, 90 feet x 15 feet x 60 feet (C), six samples from the 60-feet level (where the sulphides begin) averaged, copper, 2·78 per cent. A picked sample gave 7·5 per cent. An average of the oxidised ore at south end of cut—16 feet wide—yielded 4·04 per cent. Fine gold being also visible in panning tests.

Two hundred feet east of (C), 12 feet of auriferous stone, in a 50-feet shaft, averaged 2·0 per cent. of copper.

Twelve feet south of this shaft is another open cut (D), 50 feet x 20 feet x 60 feet deep. A sample from 9 feet wide, in west end of cut, gave 4·83 per cent. of copper; and one from the east, 4·26. Free gold in panning tests. Bottom of cut covered with débris.

Thirty-six feet south of (D), the most southern workings (E) occur. The latter form a long costeen, 120 feet x 15 feet x 6 feet deep. Copper average from ·7 to 1·2 per cent. Colours of gold only.

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The sulphides at the Kaiser Mine exposed at 60 feet do not essay well for gold; and, regarding the ascertained copper value as excessive owing to partial enrichment, the latter, in the permanent or unaltered zone, is likely to be insufficient for independent treatment, unless richer lenses are disclosed for sweetening.

Dandaloo Division.

Lady Elwyn Mine, portion 7, parish Beaconsfield, county Kennedy; 5 miles S.E. of Orange Plains, and 16 miles westerly from Dandaloo.

Inspector J. James reported (P.B. $\frac{22}{04}\frac{12}{12}$) an ironstone formation with copper ore, striking east and west, and dipping south. One hundred and seventy-five feet sunk, partly on underlay. Good patches of ore met in sinking, also in drives at 166 feet.

Fifty tons treated at Waratah at a profit. Picked sulphides assayed 20 to 22 per cent. Aided to sink from 175 to 200 feet.

"***Monarch,***" ***Elizabeth; or, No. 3 Copper Mine***, M.L. 3, parish Albert, county Kennedy; Albert Water Holes; about 300 yards from Mount Pleasant Mine. Discovered by C. J. Keenan, in 1898.—Strike N. 50° E.; dip N. 40° W. at 66°. Five shafts, ranging in depth from 40 to 150 feet, have been sunk along the lode, covering a length of 520 feet, the quartz outcrop being well exposed.

Width varies from a few inches to 3 feet in places. Stoped above 60-feet level wherever payable between Nos. 1 and 2 shafts—a distance of 300 feet.

Ninety tons of ore extracted are reported to have yielded from 16 to 36 per cent. of copper. The ore mined was evidently picked clean below, there being comparatively no seconds at grass.

A little sulphide was showing at 150 feet, lean and silicious. Water also struck at this level.

In the worked area, bunches of carbonates and grey ore were extracted, the lean silicious ore being left unstoped.

Mount Keenan, Albert Water Holes, M.L. 1, parish Tabratong, county Kennedy.—Discovered by C. J. Keenan in 1897. Strike N. 50° E.; dip N. 40° W.; channel 4 to 5 feet wide, quartz filling, good walls. Schist country. Opened to 150-feet level, driven 25 feet south-westerly. Prospector reported 30 oz. of gold dollied from surface stone; also, that 30 tons of copper ore, obtained at 50-feet level, yielded 18 per cent. of copper at Lithgow, and 11 dwt. of gold per ton. Fifteen hundredweight treated separately yielded 1 oz. of gold.

A little sulphide of copper struck at 150 feet; no further work. Not opened to inspection.

Leadville Division.

Mount Laut (formerly Mount Hope), portion 136, parish Bullinda, county Lincoln, on W. Davis' private land.—Strike N.E. in slate; dip S.W. at 68 to 78°. Channel of impregnated slate, with a little quartz, from 1 ft. 6 in. to 4 feet wide. No solid ore. Carbonates in cleavage of slates in oxidised zone. bands of sulphides below. Evidently copper solutions followed line of fissuring or jointing, and impregnated country for a few inches or feet.

Reported to have been discovered by J. Cohen, about 1890.

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MUDGEE MINING DISTRICT—*continued*.

In 1902 Inspector Polkinghorne reported two shafts, 60 and 69 feet, with veins of good ore. Formation at bottom, 3 ft. 6 in. wide. (A second lode reported outcropping south-west.) Seven and a half tons despatched yielded 21 per cent. of copper.

Aided to sink to 200-feet level (P.B. $\frac{1}{0}\frac{6}{2}\frac{2}{7}$).

Inspector James reported (P.B. $\frac{5}{0}\frac{5}{4}\frac{4}{}$) that the shaft had reached 208 feet, and the channel had been driven on 35 feet at bottom, without disclosing anything of an encouraging nature. A little scattered sulphides through the slates. Nothing to warrant further aid.

Re-opened by Laut Bros. in 1906, who confined their operations above the 90-feet level. The output, so far as can be obtained, works out 31¼ tons, yielding 14·3 per cent. of copper, about 2 oz. of silver, and a trace of gold per ton.

Parallel quartz reefs occur; the western, distant about 50 feet, the eastern, at 120 feet—unopened.

At the date of the Writer's inspection in January, 1907, the main shaft was sollared at 150 feet, preventing inspection below. At 150 feet a crosscut driven west should have cut the lode, but no trace of it is seen. At 91-feet level a stope was carried north-east for a short distance, and up about 10 feet. About 4 or 5 feet of channel slate at north-east end, but greater part carrying only strings of pyrites and a little copper sulphide. About 1 foot of more solid ore on footwall.

From 23-feet level stoped up to surface on both sides of shaft. Ore also obtained in shallow trenches, mostly to the north-east from shaft. Ore has been won from three shafts, and three open trenches aggregating 150 feet, at intervals along a length of about 400 or 500 feet.

The nature of the Mount Laut ores is shown in the following partial analyses:—

No. of Analysis.	Nature of Ore.	Copper, per cent.	Iron, per cent.	Sulphur, per cent.	Silica, per cent.	Gold, per ton.	Silver, per ton.
							oz. dwt. gr.
08-162 ..	Carbonate from surface	0·10	....	....	50·23	trace.	3 5 8
08-163 ..	Sulphides from 91-feet level	4·40	5·04	6·16	65·45	,,	1 7 5
08-164 ..	Enriched sulphides from higher level (?) (from heap at shaft).	7·12	14·56	12·17	51·85	,,	1 1 19

Unfortunately for the prospect of local treatment—if quantities warranted its contemplation—Mount Laut lode does not promise solid sulphides in the permanent zone, such as would flux the silicious superficial ores. The leafy occurrence of carbonates and oxides in the cleavage of the slates in the upper levels, is represented below by leanly distributed sulphides in a vast proportion of gangue. The absence of any iron oxide, or gossan, in the cap is also indicative of lack of solid pyritic lenses in the lode. The Mount Laut ores would, however, prove a useful flux for the massive pyritic lodes at Mount Stewart, about 9 miles distant (which see).

Mount Laut South.—About 15½ chains from the nearest point of the Mount Laut workings; to the south-west a shaft has been sunk 100 feet (?), but beyond a few stains of carbonate in a crosscut, nothing of value has so far been disclosed.

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Mudgee Mining District—*continued.*

Mount Laut, Dawson's Mine.—A recent discovery near the Mount Laut Mine, consisting of slate slightly impregnated with copper carbonates, without defined boundaries or walls.

Strike N. 60° E.; dip N. 30° W. at 80°. Shaft about 50 feet deep, showing about 1 ft. 6 in. of copper-stained slate of very low grade. An open cut on S.W. strike reveals similar carbonate stains in slate 140 feet from shaft. At 35 feet on N.E. strike a shallow cut exposes a similar occurrence.

Dandaloo Division.

Mount Pleasant Copper Mine.—See p. 254.

Mount Royal Copper Mine, M.L. 59, parish Beaconsfield, county Kennedy. 48 miles from Trangie Railway Station, and 8 miles from the surveyed Bulbodney Railway line.—Discovered by H. Fishpool, October, 1903.

Strike N. 80° E.; dip S. 10° E. at 45°. The dip flattens to 25° between the 110 and 150 feet levels, then steepens to 45°. Schist country.

Opened by three shafts—No. 1, "main," 240 feet on underlay; No. 2 (150 feet easterly) cuts the lode at 75 feet; No. 3, 18 chains westerly, 38 feet. Outcrop strong at west end, not discernible at east. Here in the main shaft a small rich vein, 4 to 6 inches thick, was followed down to 80 feet, when it began to widen gradually until it attained 6 feet at 110 feet.

Sulphides begin at 170 feet, and become massive at 200 and 240 feet.

At 110 feet the lode has been driven on for 120 feet westerly, and 130 feet easterly, to connect with No. 2 (vertical) shaft. The lode at this level has been moved slightly by a fault near No. 2 shaft. A sample of the partially enriched sulphides at 200 feet yielded:—

No. 07-2371—Copper	5·55	per cent.
Iron	37·66	,,
Sulphur	39·14	,,
Silica	13·58	,,
Gold	4 dwt. 8 grs.	per ton.
Silver	1 oz. 19 dwt. 14 grs.	per ton.

An excellent smelting composition; but very urgent that the copper value of the unaltered zone be proved.

Stopes 120 feet long and 15 feet high at the 110-feet level, and 10 feet high at the 150-feet level, east of No. 1 shaft, yielded, between 1904 and 11th May, 1907, 220 tons 16 cwt. 2 qrs. of ore, realising £2,785 3s. 2d. Two and a half tons of the enriched sulphides from the 200-feet level yielded 7½ per cent. of copper.

At the west end, where outcrop is strong, silicious, and gossany, 7 tons from the 39-feet underlay shaft, yielded 21 per cent. of copper.

Southerly from the west shaft, a vertical shaft cut copper ore at 77 feet, apparently a parallel lode, unless the dip of the Mount Royal lode suddenly changes.

In March, 1907, the mine was sold to Sydney investors, who erected a reverberatory furnace, which was started at the end of October. From 1st November to 27th February, 1908, 780 tons of ore were smelted for 65 tons of 66 per cent. matte.

The Writer is indebted to Mr. G. A. Pechey, manager and metallurgist, for the following particulars of developments since last inspection:—

"*Mount Royal Mine*, 18th April, 1908.—No. 1 shaft has been sunk 240 feet on the underlay. From this shaft, *No. 1 level* (150 feet from the surface) has been driven 180 feet *east* along the lode, which along this level has an

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average width of 4 feet. Stoping has been done all along this level. The *west* level has been driven 150 feet, the lode being an average width of 4 feet. The face of this drive is now in very good red oxide and carbonate ore. Stoping has been done all along this level up to the intermediate level, and also underhand.

"*No. 2 level* (200 feet) has been driven 30 feet east and 28 feet west, the lode at both ends having an average width of 5 feet, the ore being solid sulphides, very suitable for pyritic smelting.

"*No. 2 shaft*, situated 1,200 feet west of No. 1 shaft, has been sunk 100 feet vertical, but where the lode underlays through the shaft at a depth of 70 feet, it has been converted into an underlay shaft for an additional depth of 67 feet, making a total depth of 137 feet. From the bottom a level is being driven *east and west* in good sulphide ore of an average width of 3 feet. The east drive is in 40 feet, and the west, 30 feet, and stoping has been done from this level up to the line of demarcation between the sulphides and oxidised ore. The latter ore from this section of the mine is mostly solid grey ore. The sulphide ore from this shaft is heap roasted before being smelted. The drives west from No. 1 shaft, and east from No. 2 shaft, are now being extended with the intention of connecting the shafts. The faces are both in good ore, and the lode can be traced on the surface from shaft to shaft.

"*Plant.*—At No. 1 shaft, poppet legs, winding winch, and boiler have been installed. A reverberatory furnace, 24 feet x 14 feet, inside measurement, has been erected, and is now smelting about 77 tons of ore weekly.

"*Men employed.*—A total of fifty-two hands are at present employed in the mine, on the surface, and at the smelter.

"*Smelting return from 1st November, 1907, to 18th April, 1908* (stopped nine weeks, holidays, repairs, &c.) :—

Ore Smelted.	*Product obtained.*
1,154 tons oxidised and sulphide ore, average assay value 7·01 per cent. copper.	111 tons 6 cwt. of matte, of average assay value of 61·6 per cent., containing 69 tons of copper. Equal to 6 per cent. of copper from the ore.

Average slag assays—	Copper	0·78 per cent.
	Oxide of iron (Fe O)	42·70 „
	Insoluble	55·80 „
	Lime	trace.
	No flux used.	

"An economical and effective method of producing a high grade matte is used. During ordinary ore smelting a matte of 40 to 45 per cent. is produced, the matte being retained in the furnace till the fourth day, when a charge of the higher grade oxidised ore (without any sulphide ore) is given. This is smelted in eight hours, and the matte brought up to over 60 per cent. By this means the usual delay in roasting the matte is avoided, and the furnace is kept continuously smelting ore, and at the same time producing comparatively low slag loss."

The sulphides from No. 2 shaft are clamp roasted. The recent smelting proportions being :—

Oxidised ore	38 tons.
Roasted sulphides	24 „
Raw sulphides	14 „

Smelting ceased early in June, 1908. Developmental work only being carried on. No. 1 shaft being deepened to 400 feet.

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Leadville Division.

Mount Scott, near Leadville.—Strike N. and S.; dip west at 45°. Opened by two shafts. Lode channel 5 to 6 feet wide. Vertical shafts to 140 feet. Winze below to 170 feet, following underlay on a dip of 42°. Footwall not showing at bottom. A little galena and zinc-blende making on hanging wall. Channel filling mixed with country.

An average sample of lodestuff yielded:—

No. 08–172—	Zinc	12·79 per cent.
	Silica	25·38 „
	Lead	1·00 „ (about).
	Copper	none detected.
	Gold	a trace per ton.
	Silver	16 dwt. 8 grs. per ton.

A sample picked for supposed copper ore also gave negative results on assay.

Mount Stewart Mine, M.Ls. 1, 2, 3, parish Talbragar, county Bligh.—Leadville, 3½ miles from nearest point of Mudgee–Dunedoo Railway line in course of construction. Opened in 1888 as a silver-lead mine. A water-jacketted blast furnace was erected in 1892.

During the smelting campaign—lasting for fourteen months—6,464 tons of ore were smelted for 1,539 tons of lead and 292,093 oz. of silver (according to Mr. C. L. Garland), a yield equivalent to 23·8 per cent. of lead and 45 oz. of silver per ton.

In July, 1898, the mine was purchased by Messrs. Garland and Channon, who have since carried out a considerable amount of development.

Several large parallel lenses, with strong gossan outcrops, occur in quartz-felsite, quartzite, granulite, and limestone. Striking from N. 25° to N. 75° E., and dipping westerly at 60 to 75°.

The provings extend for about 2,000 feet along the strikes, but are not continuous, the principal workings being at the north-east and south-west ends.

The Western Lode (north-west end), which is the site of the original discovery, lies about 170 feet west of the "Main," or central lode, with the engine shaft of which it is connected at the 200-feet level.

The "East," or Paddock Lode, lies east of the "Main," but has not been connected.

At the south-west. or Extended Block, end, two lodes have been opened; a strong gossan outcrop to the west is practically unopened.

From surface indications it is probable that extended connection between the extreme end workings will reveal a series of large, more or less disconnected lenses, of kindly gossany nature in the oxidised zone, and strongly pyritic below it. The outcrop of this metalliferous belt is traceable some distance south-westerly beyond the Extended Block.

The "Main" lode has been driven on for about 600 feet at the north-east end—at the 157-feet level, the oxidised ore being stoped to surface in parts for lead and silver. Below 157 feet sulphides begin; principally solid pyrites, with appreciable quantities of silver in limited areas, though the general average is unfortunately low. Lead sulphide, however, is not prominent for the most part. The width averages from 15 to 40 feet. The composition of the pyritic ore is shown approximately in Assays Nos. 08–165, 168, and 171.

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In the connecting crosscut at the 200-feet level from the engine shaft to e West lode, the following rocks were cut through:—

7147—Quartz-felsite.
7148—Quartzite.

mestone occurs on south-west side of the West lode, and beyond this a osscut exposed a coarse porphyritic rock, determined as granulite—obably crushed granite (7149, 7150). The quality of the limestone—which as used for flux during smelting operations—is shown in Assay No. 08–174. mestone of a similar character occurs also about 2 miles north-easterly from ount Stewart.

The West lode has been sunk on to 260 feet. It strikes N. 75° E., and ps N. 15° W. This lode is composed largely of zinc-blende and pyrites; out 40 feet wide. Made into limestone; zinc making again below 150 et.

The East, or Paddock, lode, at the north-east end, strikes N. 25° E., and ps N. 65° W. at 56°. Width of lode about 40 feet. Composed largely zinc-blende, pyrites, and carbonate of lead. Opened by underlay shaft a depth of 170 feet.

Principal attention was given to the south-west end in the Extended Block—here copper ores become appreciable; for the future of the mine entirely pends upon developing, or securing elsewhere, sufficient copper to form atte and collect the silver and gold of the kindly pyritic ore in the northern ction, which is so eminently suitable for partial pyritic smelting.

Copper ores in this section were first encountered in the West lode in the d copper shaft—145 feet deep. This lode strikes N. 75° E., and dips 15° W. at 76°.

From 100 to 145 feet levels copper sulphate coats the exposed kindly ssany lodestuff; the width at 145 feet is about 20 feet, but part of the ngue is kaolin. The metallic values of this ore from the width mentioned, d a length of 45 feet, are shown in Assay No. 08–166. This lens has not en tested below about 155 feet. The ore here is partly decomposed rites and chalcopyrite, which gives rise to the sulphates on exposed rfaces.

From the 145-feet level connection is made with the East lode. A shaft s been sunk in the latter 200 feet. A lens of copper-bearing lodestuff tends up about 30 feet above this level, forming a shoot of about similar ameter; its quality is shown in Assay No. 08–170. The thickness of the st lode ranges up to 70 feet.

Copper ore is also exposed in No. 2 winze, the quality of which is shown Assay No. 08–167. Also in No. 3 winze from the intermediate level, st lode, 60 feet below the 145-feet level, where it begins at 190 feet from rface, and extends down as far as the winze goes, viz., to 210 feet. Here phides with sulphate efflorescence are exposed. This lens of cupriferous has an apparent width of 30 feet.

Zinc-blende makes strongly on hanging wall of the East lode at 200-feet el, averaging 4 to 5 feet in width, and assaying 41·32 per cent. of zinc say No. 08–169).

Zinc also makes strongly in a crosscut under the West lode; it is, however, low grade, being mixed in part with limestone. An average of 16 feet e in the crosscut, without excluding anything, shows the composition cted in Assay No. 08–168.

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Mudgee Mining District—*continued.*

Zinc also makes prominently, as before stated, in the Western and Paddock workings at the north-east end.

If it were not for the vast zinc by-product of the Broken Hill lode, those of Mount Stewart would probably be worked for their zinc contents as a primary product. In any future operations it must be reckoned as an essential item. Even if—as is hopeful—sufficient copper be obtainable in the mine or district, to enable partial pyritic smelting to be established, separation of the zinc in commercial form will be a necessity, both for revenue and for effective furnace work. Doubtless much clean pyritic ore could be selected comparatively free from zinc; but the only adequate and economic method in a low-grade deposit, is to work it all on a large scale. Mount Stewart ore is suitable for magnetic concentration, and the mine product could probably be roughly classified into concentrating and direct smelting ore.

In the event of re-establishment of smelting at Mount Stewart, the question of fuel will become prominent. Though the Upper Coal Measures extend into the district of the Talbragar, it is doubtful whether the coal seams in them are of sufficiently good quality for coking or firing purposes. So far as proved, in Ballimore Bores and in several wells, the quality has been inferior.

In the event of being forced to seek further afield, the advent of the railway within about 3 miles of the mine will largely reduce the disabilities previous smelting laboured under. Excellent coal for all purposes is procurable alongside the railway at Cumber Melon, near Rylstone, or even from Coxs Siding, distant about 76 miles by rail from Mount Stewart.

Mount Stewart pyritic ores would form a valuable flux for siliceous copper ores such as the Mount Laut, or *vice versâ*.

Assay No.	Description.	Copper, per cent.	Zinc, per cent.	Iron, per cent.	Lead, per cent.	Sulphur, per cent.	Silica, per cent.	Gold, per ton.	Silver, per ton.
								oz. dwt. gr.	oz. dwt.
08-165..	Average of 30 feet of solid pyrites, Main lode, 200-feet level.	..	0·65	40·04	..	45·37	9·00	trace.	3 2
08-264..	Average from 2 tons of large blocks sent to Franco-British Exhibition from same lode, upper level.	0·85	2·22	..	1·30	..	..	0 6 13	59 11
08-171..	Average from Main lode, 217-feet level, 300 feet south of No. 08-165.	0·20	..	..	0·20	..	..	0 4 8	14 19
08-166..	Copper gossan, West lode (south end), Extended Block, 145-feet level.	4·05	0·76	..	1·00	..	39·60	trace.	0 13
08-167..	Gossan from East lode (south end), Extended Block, over No. 2 winze.	0·50	0·56	..	2·00	..	16·75	0 1 2	38 7
08-168..	Zinc-blende, West lode, Extended Block, 200-feet level.	..	12·95	..	..	..	..	trace.	0 13
08-169..	Average of zinc lode, hanging wall, East lode, Extended Block, 4-5 feet wide.	..	41·32	..	..	..	..	trace.	6 12
08-170..	Copper ore from lens in East lode, Extended Block.	3·72	5·26	17·78	..	21·68	25·12	trace.	1 6

08-174—Limestone from West lode, north end.	Calcium carbonate	97·67
	Ferric oxide and alumina	·18
	Gangue*	2·20
		100·05

* Contains a small amount of carbonate of magnesia—less than 0·1 per cent.

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Mudgee Mining District—*continued.*

During the smelting campaign the enterprise had to contend with the following transit charges:—

Coke from Rix's Creek, Singleton (rail to Mudgee), 17s. 6d. per ton.
Coke from Mudgee to mine (50 miles), from £1 to £3 per ton.
Bullion from mine to Mudgee (50 miles), from £1 to £3 per ton.
Bullion, rail (Mudgee to Sydney), £1 10s. per ton.

Gulgong Division.

Native Bee Mine, on S.E. strike of Belara Lode, portion 131, parish Worobil, county Bligh.—Discovered by W. Spicer and L. Davis, October, 1906, in W. Harvey's private land. Occurs under similar conditions to the Belara, in slate country near intrusive quartz-felsite. Strike N. 30° W., dip N. 60° E. at 65°.

Opened by four shafts. Proved for a length of about 450 feet, and to depths ranging from 76 to 90 feet.

Development.—No. 1 shaft, 90 feet deep, driven north-westerly at 60 feet level for 30 feet, and south-easterly for 25 feet; lode 9 inches to 2 feet wide.

No. 2 shaft (78 feet south-easterly from No. 1), 76 feet deep, driven north-westerly for 30 feet at 56-feet level, and south 20 feet. Winze from north drive down 20 feet. Lode thin—6 inches quartz with carbonates.

No. 3 shaft (78 feet north-westerly from No. 1), 90 feet deep, driven north-westerly for 30 feet at 70-feet level, and 30 feet south-easterly.

No. 4 shaft (270 feet north-westerly from No. 3), 70 feet deep, driven south 20 feet at 60-feet level.

Output.—Eighty-eight and half tons of rich oxidised ores sold to Great Cobar, Ltd., at Lithgow, yielded from 25 to 28 per cent. of copper. Thirty-six and a half tons were treated locally by Messrs. Cock Bros., in the Belara furnaces; 34 tons of which yielded only 4·6 per cent Thus reducing the average yield to 16·78 per cent. of copper, 8·6 oz. of silver, and a trace of gold per ton. Aided from the Prospecting Vote (P.B. $\frac{1}{0}\frac{8}{8}\frac{2}{8}$) to sink to 200-feet level.

Dandaloo Division.

Orange Plains Copper Mine (also known as "Ironstone"), M.Ls. 11, 19, 23, parish Beaconsfield, county Kennedy, near the Mount Royal Mine.—Solid outcrop of ferruginous quartzite, and iron oxide. Strike apparently east and west; dip south at 45°. Opened by 150-feet shaft (to March, 1907), following underlay. Sulphides at this level enriched; an average sample assayed:—

No. 2376—Copper	11·7	per cent.
Iron	35·70	,,
Sulphur	39·99	,,
Silica	8·48	,,
Gold	2 dwt. 4 grs.	per ton.
Silver	8 ,, 17 ,,	,,

A level 50 feet west, and 18 feet east, at 108-feet level. Ore stoped from east end. Crosscut north through schist with copper stains.

Reported output, 24 tons, averaging about 18 per cent.

Peak Hill Division.

Peak Hill Gold Mine.—In 1900 about 11 tons of copper were obtained during gold-mining operations. The sulphides (pyrites) from lower levels treated in a small experimental blast furnace, yielded from 1 to 1½ per cent. of copper, and 7 to 12 dwt. of gold per ton.

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MUDGEE MINING DISTRICT—*continued.*

Rylstone Division.

Queen of the Stream Lode, Running Stream, about 4½ miles westerly from Capertee, parish Rylstone, county Roxburgh.—Discovered by Franks and party, June, 1897. Inspector H. Hooke reported (P.B. $\frac{1}{5}\frac{1}{6}\frac{1}{1}$): "Slate traversed by quartz veins carrying copper sulphides. Aided to sink 50 feet."

Inspector J. Polkinghorne reported (P.B. 99-5,885): "Several openings showing a series of veins of copper and lead ores, but nothing defined. Aided to continue to 100 feet. At 25 feet struck small vein of grey ore. At 43 feet copper pyrites. Rate increased at 52 feet. No further record."

Wellington Division.

Rose Hill Copper Mine, about 4 miles south of Geurie Railway Station, parish Mickety Mulga, county Lincoln.—The Warden in 1888, p. 70, reported that three shafts had been sunk on a lode about 2 ft. 6 in. thick, and well defined, the depths of proving being 25, 40, and 90 feet. The ore consisted chiefly of yellow sulphide. A trial parcel of 4 tons was sent to the Waratah Smelting Works; but as work ceased in 1889, it is presumed that the result of the trial was not satisfactory.

Dandaloo Division.

Sydney-Wallaroo Copper Mine (late Caroline), M.Ls. 1 and 17, parish Caroline, county Kennedy, about 15 miles from Dandaloo, 45 from Trangie Railway Station, and 13 from Bogan Gate-Bulbodney surveyed line.—Opened about 1888 to a depth of 140 feet; taken up again in 1898 by a Cobar syndicate, which supplied the following particulars through the late Mr. W. Gillard, of Cobar, under date of 7th September, 1898:—

"We thoroughly overhauled the surface of the mine, and found that there are three shafts—one supposed to be 140 feet deep; this shaft is 8 feet x 4 feet. The next shaft is supposed to be 50 feet deep. The other shaft is 14 feet deep. The 140-feet shaft is on the eastern side of the lode. The 50 feet is on the lode, which is 3 feet wide at the bottom of the shaft, containing very good carbonate ore. The lode strikes north-westerly in a 40-acre block. The net profit on 6 tons 14 cwt. of ore, sold in March, was £36 7s. 6d. The next parcel, of 6 tons, treated in May, returned a net profit of £27 4s. (sold to the Great Cobar Syndicate). The ore will average above 14 per cent. of copper. The amount expended on the mine was about £200. Mineral lease granted on 11th May, 1898, to W. Meriel and W. Rowe."

Position in March, 1907.—Strike N. 20° W.; dip N. 70° E., at about 50°. Outcrop well defined, but not prominent. Proved for about 12 chains, by shafts. Principal workings close to boundary of M.Ls. 1 and 17. Greatest depth, 140 feet.

Lode consists of impregnated contorted schists, resembling those of Girilambone. Greatest proved width of impregnated country, 20 to 30 feet.

Seven chains south of main shaft, Keenan Bros., who secured the property in 1905, cut the lode at a depth of 35 feet, and raised about 4 tons of fair grade ore.

A belt of hard ferruginous quartzite occurs a little east of the lode; further south it has been opened by shaft and open cut without disclosing any values. Its highly ferruginous outcrop simulates a lode.

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The early workings have not been deepened or extended. Pockets and veins of carbonates and grey ore have been more or less exploited in the oxidised zone, but not to any great extent. Keenan Bros. raised 10 tons from a shallow level for a reported yield of 12 to 17 per cent. copper.

At the deepest level—140 feet—the transition to sulphides is revealed, though not completely; if anything there is slight enrichment at this level. An average sample chipped from a width of 28 feet of pyritic schist yielded:—

No. 07-2372—Copper	2·55	per cent.
Iron	20·72	,,
Sulphur	13·00	,,
Silica	35·08	,,
Gold	3 dwt. 6 grs.	per ton.
Silver	7 ,, 15 ,,	,,

Further prospecting in the sulphide zone is necessary to determine the value of the deposit. At the level mentioned the sulphides are not sufficiently solid and homogeneous for partial pyritic smelting.

In June, 1907, an Adelaide syndicate was reported to have taken over the mine.

Inspector J. Polkinghorne reported that 60 tons of ore were raised during 1907, and disposed of for £960. (Ann. Rept., 1907, p. 91.)

Underlay Mine, M.Ls. 4, 5, 6, 7, 22, parish Beaconsfield, county Kennedy, 16 miles from Dandaloo.—Discovered by J. Dunwell in 1903. Strike N. 55° E.; dip S. 35° E., at about 45°.

Ore lens opened by two shafts 130 feet apart to depths of 150 and 200 feet. Copper ore struck at 104 feet, followed down to 165 feet; driven on 130 feet at this level. Stoped up to 100 feet. Shaft passed into country below 165-feet level.

At south-west end of drive at 128-feet level in new shaft, the lode believed to have been faulted to the south. The fault plane being smoothed and slickensided, search not made directly opposite junction. Fault plane driven on south 40 feet, when ferruginous quartzite was cut. Drove from this point to old shaft (150 feet). Country disturbed. The ore gave out at 200 feet in main or new shaft—the schist being wonderfully contorted; hard intercalated bands of quartzite presenting complete corrugations; at this point the ore ceased.

At the 163-feet level, rich thin veins of copper and iron pyrites occurred, yielding by assay—

No. 07-2376—Copper	13·52	per cent.
Iron	34·58	,,
Sulphur	36·82	,,
Silica	11·02	,,
Gold	trace	per ton.
Silver	2 dwt. 4 grs.	per ton.

From the lowest level where granular pyrites are developed, a sample yielded:—

No. 07-2375—Copper	2·17	per cent.
Iron	32·90	,,
Sulphur	32·88	,,
Silica	23·84	,,
Gold	trace	per ton.
Silver	16 dwt. 8 grs.	per ton.

150 feet from the old shaft, on underlay side, a large formation has been exposed in a trench, which deserves attention at lower levels.

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MUDGEE MINING DISTRICT—*continued*.

The output to end of 1906 is stated by the owner to have realised £1,875 net; which, at the average rate of local yield, would equal about 104 tons. A considerable quantity of seconds are at grass, very silicious, but workable locally with massive sulphides, such as occur in other neighbouring lodes at Orange Plains.

The following particulars of development and output since inspection in 1907 were supplied by Mr. Dunwell, under date 11th January, 1908:—

Drove 52 feet easterly in No. 2 shaft at 137-feet level. At 12 feet struck a fault, drove through it, and struck lode 8 feet wide, consisting of ironstone and pyrites, with a little grey and black ore. At 52 feet the lode turned and is now going north, about 4 feet wide; vertical, with clean walls.

A western drive from same level for 32 feet through gossany ironstone with a little copper. No walls showing.

Additional output—46 tons 19 cwt. 3 qrs., averaging 17½ per cent. of copper.

Wellington Division.

Wellington District.—C. S. Wilkinson, Government Geologist, in 1876, reported that the formations at Wellington consist of a thick series of sandstones, shales, conglomerates, and limestones, provisionally classed as Upper Silurian, traversed in places by greenstone dykes. The dykes are in some places traversed by quartz reefs containing grey sulphide and carbonates of copper.

In 1886 the Mining Registrar reported that 300 tons of ore had been smelted for a yield of 40 tons of copper, but no particulars of localities are given.

Copper ores were reported in the following localities:—

Fittes' Mine, about 12 miles from Wellington; working in 1876. An assay of copper glance and pyrites yielded 10·04 per cent. of copper, and 7 oz. 14 dwt. 10 grs. of silver per ton.

Weandre Creek, parish Three Brothers. Copper reported present in most of the reefs of this locality.

Wellbank—

The Springs railway station.

Lindberg's Mine, Wellington Common.

Apsley Mine, Wellington Common.

In 1882 a small smelting furnace was erected near Wellington at a cost of £450, and ores from the Apsley and Lindberg's Mines were tested, with poor results.

In 1898 the Warden reported that applications had been lodged for copper lands at the following places in his district, but that little real work had resulted:—

Wellington Common.

Galwadgery Creek.

Ponto, near Wellington.

Garry Owen—carbonate ore assaying 3 to 6 per cent.

Newrea.

Three Mile Flat—assaying 13 per cent.

Goolma Creek. (Belara ?)

Kadumble Range.

Kaiser Mine.

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MUDGEE MINING DISTRICT—*continued.*

Apsley Mine, close to Apsley platform, about 2 miles east of Wellington.—Ore taken from this mine (in andesite) was dressed and despatched to Lloyd's Lithgow Smelting Works by W. P. Mitchell, the returns from 4 tons 17 cwt. being—copper, 7·9 per cent.; silver, 2 oz.; and gold, 7 dwt. 13 grs. per ton.

Aid granted (P.B.$\frac{1}{0}\frac{1}{1}$) to sink from 25 to 75 feet. At 50 feet traces of copper in gossan. Fruitless.

Tremayne Bros. Black Rock property, 9 miles from Wellington.—Copper reported in September, 1907; ¼ mile from Bell River, between it and Molong-road. Cuprite in andesite close to junction of limestone. Several shallow openings showing copper ore.

Commonwealth Mine, Yarragol, about 9 miles from Wellington.—Originally profitably worked for gold in oxidized zone, but became very refractory below water-level. The ore being a complex mixture of zinc, lead, iron, and copper, with a little gold and silver. The copper runs to about 1½ per cent.

Wellington Champion Hill Lode.—Reported that a furnace was erected here twenty years ago.

In the andesitic rocks of Wellington, Blayney, and Carcoar, native copper is frequently found in small isolated pellets and in thin veins. The weathering and decomposition of the metal in the exposed outcrops of the andesite has stained it in many places, inducing prospecting for lodes—but none have eventuated in the solid rock.

Mudgee Division.

Wilbetree.—In the latter part of 1896, a newly-discovered copper lode in R. Atkinson's land at Wilbetree, 9 miles north-west of Mudgee, was opened up. A shaft was sunk 60 feet, which cut through the lode at 13 feet. The outcrop reported from 12 to 15 feet wide, showing carbonates. Work soon abandoned without any tangible results being obtained.

Wellington Division.

Yarragol Copper Mine, portion 40, parish Yarragol, county Bligh, about 4 miles from Dripstone Railway Station.—Originally opened about 1878. Taken up again by Aaron and party about five years later. About 3½ tons carbonates, and 2½ tons sulphides, raised during the operations of the Woolaman Mining Syndicate, realised at Lloyd's Smelting Works, Lithgow, 9 and 6 per cent. of copper. The developments consist of a 30-feet shaft sunk by the first prospectors, and a 60-feet shaft sunk by the last at some distance from the former. A crosscut from the latter, however, failed to reach the lode. This caused some of the shareholders to abandon their interests, and the closing of the mine.

Re-opened during 1906. Second shaft deepened to 110 feet; 4½ tons of ore reported to have been treated with good results.

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NEW ENGLAND MINING DISTRICT.

Kookabookra Division.

Aberfoyle Copper Lodes, M.L. 5, parish Allingham, county Clarke.—In June, 1907, a syndicate was formed to develop several outcrops of copper ore at Aberfoyle River, about 45 miles from Armidale.

Later it was reported that a lode had been cut in several places about 800 feet below the plateau level on the steep falls therefrom. Other outcrops occur about half a mile south. The following assays were made:—

07-1741—Quartz with sooty copper pyrites, yielding:—

Copper	6·60 per cent.
Silver	9 oz. 16 dwt. per ton.
Gold	a trace per ton.

07-1742—Quartz with sooty copper pyrites, yielding:—

Copper	8·07 per cent.
Silver	5 oz. 2 dwt. 8 grs. per ton.
Gold	a trace per ton.

Reported abandoned on the 18th January, 1908.

Adjoining the above lease P. Meehan was prospecting for continuation of above lode. Aid refused.

Drake Division.

Adeline Mine, Drake, parish West Fairfield, county Drake.—E. C. Andrews, Geological Surveyor, states (Ann. Rept., 1903, p. 132), that at least three distinct lines of reef occur in this property.

The "Main lode" had then been driven 150 feet at the 100-feet level and 500 tons of ore extracted, of a value of 5 per cent. copper and 5 dwt. of gold per ton, from a width of 4 feet of lodestuff.

The main shaft was down 310 feet and intercepted the main lode at 150 feet. The lode dips west at 45°. A crosscut from the 300-feet level was being driven to cut it.

The "Second" lode, lying to the south, had been driven on 240 feet; smelting ore being extracted from a length of 200 feet, and an average thickness of 2 feet.

The deepest shaft on the "Second" lode being 120 feet. Ore stoped between the 50 and 80-feet levels, yielded 600 tons of firsts, averaging 3 oz. of gold per ton, and 9½ per cent. of copper.

Nine hundred tons of seconds averaged 12 dwt. of gold per ton, and 3 to 4 per cent. of copper.

The ore consists of chalcopyrite in quartz, with a little pyrite.

According to the Annual Report for 1906 (p. 48), this mine had been idle for the previous two years. During the latter, 39 tons, picked from old dumps, realised £250 for copper and £121 for gold.

According to Mr. Gunlach (13/9/05) the surface ores were solely auriferous, but changed at a shallow depth to silicious copper ores. Strike of veins, N. and S.; dip, westerly, at an average of 45°. Country, andesite,

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rhyolite, and breccia. The two veins at present developed occur about 2 chains apart. The early output is not known, but since the Adeline Company had possession, the following output has been won, according to Mr. Guhlach:—

About 2,000 tons ore raised, which yielded 1,600 tons, comprising—650 tons of firsts, realising 3 oz. of gold per ton, and 8 per cent. of copper; 105 tons of concentrates, realising 15 dwt. of gold per ton, and 12 per cent. copper; 850 tons seconds (at mine), valued at 14 dwt. gold, and 5 per cent. copper.

(See also returns under *Drake*.)

Emmaville Division.

Bald Nob Mine, about 5 miles north of Emmaville.—Native copper occurs in fluorspar at the 90-feet level in the Bald Nob Tin Mine. The most interesting feature of the occurrence is the association of tin and copper, other instances noted in the State being at Gumble near Molong, Ottery, Royal George Mine (Tingha), and other New England tin lodes. Chief Inspector J. B. Jaquet, who visited the mine, states that the same conditions obtain at Bald Nob as in the Dolcoath Mine in Cornwall, where copper gave place to tin in the lower levels. At Bald Nob, for 30 feet from the surface, good copper ore was obtained; below this the lode became poor. At 70 feet, apparently where the diorite was entered in the shaft, tin ore came in in limited quantity in the form of a rich bunch. At 90 feet, in a drive easterly, native copper occurs in fluorspar, also a bunchy deposit, probably an impregnation along the junction of the sedimentary and intrusive rocks of which the country consists. The diorite in the vicinity of the shaft is impregnated with copper pyrites. A few tons of very rich copper ore were obtained, but the tin ore was not sufficient to pay.

This mine was opened, about 1873, to a shallow depth. A shaft was sunk 90 feet at the junction of diorite and claystone.

Drake Division.

Bates' Lode, about 40 chains north-west of Minnie Copper Mine, parish Ewingar, county Drake.—Strike N. 20° E., in trachytic tuff, brecciated in part, resembling Drake rocks.

Discovered and superficially tested by H. M. Bates in 1907. Opened by trench. Veinstone about 14 inches at widest, mostly on footwall. South end in hard country, with a little pyrites. Of no importance.

Border Chief Mine, 2 miles west of Drake.—Inspector Carthew reported (P.B. $\frac{4}{0}\frac{8}{0}\frac{4}{0}$) a quartz reef in slate, striking N.E.

Shafts, 30 and 70 feet. Aided to continue 70-feet shaft to 100 feet.

Progress.—At 80 feet, veins of copper about 4 inches wide. At 90 feet, lode formation 18 inches wide, with small bunches of copper and arsenical pyrites. At 100 feet, vein only 6 inches wide—prospects not encouraging.

Deepwater Division.

Castle Hill Copper Mine, about 5 miles from Deepwater.—Opened by a Newcastle Syndicate.

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NEW ENGLAND MINING DISTRICT—*continued.*

The following parcels of ore from this mine were treated at the English and Australian Copper-smelting Works, Waratah:—

				oz.	dwt.	grs.	
2 tons	10 cwt.,	yielded	6½ per cent. copper and silver...	9	12	8	per ton.
	15 „	„	4 „ „	32	0	0	„
6 „	0 „	„	9¼ „ „	35	11	11	„
6 „	14 „	„	6 „ „	35	0	0	„

Castlerag, near Deepwater.—A Newcastle Syndicate opened a copper lode a few hundred yards north from the Old Castlerag Silver-lead Mine, probably identical with Castle Hill Mine. 4 tons 2 cwt. treated at the Waratah Smelting Works yielded 2½ per cent. of copper, and 22 oz. 8 dwt. 8 grs. of silver per ton.

Drake Division.

Cullen's Creek, near Rivertree.—Argentiferous copper ore occurs at Cullen's Creek. At surface the ore consists of gossan, which passes below into a mixture of copper and iron pyrites, galena, and blende. No particulars of the size of the lode have come to hand, but it is understood to be small. An assay of a sample, forwarded through Chief Inspector J. B. Jaquet, yielded 19·23 per cent. of copper, and 37 oz. 13 dwt. 12 grs. of silver, and a trace of gold per ton. Later samples yielded—$\frac{1}{0}\frac{8}{8}\frac{7}{7}$, and $\frac{1}{0}\frac{2}{8}\frac{6}{1}$, copper, 23 to 30·7 per cent.; silver, 98 to 134 oz. per ton.

Deepwater Division.

Deepwater District.—In 1885 samples from near Deepwater, consisting of iron and copper pyrites, yielded from 12 to 14·35 per cent. of copper, and 10 to 31 oz. of silver per ton. Ore from 5 miles north, probably near Castlerag ($\frac{4}{0}\frac{8}{8}\frac{6}{5}$) yielded 8·49 per cent. copper, and 20 oz. 15 dwt. 22 grs. silver per ton; $\frac{4}{0}\frac{1}{7}\frac{2}{4}$ yielded 17·87 per cent. copper, and 32 oz. 1 dwt. 8 grs. silver per ton; $\frac{2}{0}\frac{9}{8}\frac{5}{5}$ yielded 16·60 per cent. copper, and 18 oz. 1 dwt. 12 grs. silver per ton.

The "Iron Lode" near Castlerag Silver-lead lode, was opened in early days of silver-mining. It is reported to be 12 inches thick, carrying copper ore. A shaft was sunk upon it about 60 or 80 feet, and a tunnel driven 400 feet; a little sulphide and carbonate ore being still at grass. Lease applied for by F. Thompson, Deepwater, in 1907.

Emmaville Division.

Copper ore associated with wolfram and mispickel has been noted in small quantity by Geological-Surveyor Andrews about 1¼ miles N.N.W. of Emmaville, the copper occurring as chalcopyrite in granite; a pipe-like occurrence near the junction of sedimentaries.

Drake Division.

Mr. J. P. Curran, Warden's Clerk, Drake, kindly furnished the following report on the copper output of the Drake Mining Division during 1907:—

"The output for 1907 has been very small, as the miners have to send their mineral to distant smelting works for realisation, consequently, nothing lower than 20 per cent. ore will pay for shipment, which means that a large quantity of lower-grade mineral must be temporarily discarded. Present indications, however, point to a much larger output of copper ore during 1908. Messrs. Baker Bros. are erecting concentrating and smelting works in a central part of the field. If their system of treatment is successful, the

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miners will have the opportunity of disposing of their ore locally; and several mines which have been closed down will resume work, and others may spring into existence.

PRODUCTION of Copper Ore in the Drake Mining Division (J. P. Curran).

1899	.....			
1900	.....	230 tons,	value	£1,660.
1901	.....	1,197 „	„	£5,930.
1902	.....	1,666 „	„	£7,523.
1903	.....	975 „	„	£2,361.
1904	.....	111 „	„	£635.
1905	.....	24 „	„	£289 (Australian Smelting Co., closed).
1906	....	157 „	„	£1,594.
1907	.....	559 „	„	not disclosed.

"*Return of production for* 1907.—P. Donnellan & Co., 'Baal Gammon Mine,' 47 tons ore, yield 7½ tons copper. McCrossin & Co., 'Lady Mary Extended Mine,' 29 tons ore, yield 4½ tons copper. Pioneer Co., 'Pioneer Mine,' 425 tons ore, yield 14½ tons copper. McAuley & Co., 'Lady Mary Mine,' 14 tons ore. J. Parker, 'Rainbow Mine,' 44 tons ore."

Drake.—The Drake, or Fairfield mining centre, began with gold and silver mining, but at the sulphide zone, copper gradually became prominent. Geological-Surveyor Andrews (Ann. Rept., 1903, p. 132) described the metalliferous occurrences as follows:—"The ore bodies contain gold, copper, silver, lead, and zinc. Certain reefs contain gold and copper alone; others, again, have these metals intimately associated with lead and zinc, also small quantities of silver. The ordinary vein material has the appearance of auriferous quartz with mixed sulphides—averaging from 15 to 20 per cent. of the whole. Extreme cases (Pioneer No. 1) contain 40 per cent. sulphides, mostly as iron. The gangue is thus seen to be highly silicious in character, with a minor percentage only of mixed sulphides. The reefs were originally worked for gold, but free milling soon became impossible, and at present the copper is the most valuable product. This metal, which rarely makes its appearance above the 100-feet level, is present to the extent of from 4 to 5 per cent. of the vein material."

Several of the principal lodes have been noted herein under their specific names. Other occurrences of copper-bearing veins are:—

McAuley and party's, on north slope of Mount Carrington, on which six shafts have been sunk to various depths, and connected by a main drive. The principal operations lie between No. 1 shaft (100 feet) and No. 2 (80 feet). In a level from the 80-feet shaft, a drive for 120 feet reveals a width of 3 inches to 1 foot of veinstone; 11¾ tons ore obtained, yielded 2·3 per cent. copper (*ibid.*, 1907, p. 54).

Rainbow Mine, on south slopes of Mount Carrington, and adjoining Pioneer Mine. In 1907 Parker and party drove along the lode 70 feet, and stoped along back of lode for 80 feet; 44 tons copper ore raised, valued at £220 (*ibid.*).

About 3 miles south of Drake a formation is reported by J. P. Curran, Warden's Clerk, with indications of copper lode; bunches of carbonate 2½ inches wide occurring, but at 18 feet are reported to have pinched, with less encouraging prospects.

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NEW ENGLAND MINING DISTRICT—*continued*.

Donnellan and party, at Sawpit Gully, sank two shafts of 50 feet each, in their lease, and connected them by a drive 200 feet long. The lode averages about 3 feet wide. Two men won 47 tons of ore, yielding 7½ per cent. of copper (*ibid.*).

No. 9, *Drake*.—Geological-Surveyor Andrews reported: shaft over 100 feet deep on well-defined lode. Gangue quartz with abundant zinc (*ibid.*, 1903, p. 132).

M.L. 10, *Drake*, parishes Gerard and West Fairfield, county Drake.—At Sawpit Gully. J. P. Curran reports (P.B. $\frac{1}{9}\frac{0}{0}\frac{2}{2}$): Shaft 26 feet, lode formation 7 feet wide. Three veins in shaft—western, 1 foot thick; centre vein, 1 foot; and east vein, on hanging wall, 2 feet wide. Lodestuff quartz with small bunches of black and yellow ore—average low.

Strike N.N.E., traceable 4 or 5 chains. Aid granted for 50 feet of sinking. No record.

Geological-Surveyor Andrews states that the Straus, Watson's Block, the Lead Block, Nil Desperandum, Hogg's Line, Lone Hand, Hot Scone, and other reefs in the neighbourhood of Drake, are more or less well defined, and contain, approximately, the same amounts of copper and impurities as in others enumerated (*ibid.*, 1903, p. 132).

Emmaville Division.

Emmaville.—Copper ores have been reported from several localities in the Emmaville District, but no lodes have yet been worked to any extent. At Hall's Grampians, portion 600, parish Strathbogie North, Professor T. W. E. David reported "Reid's copper lode" as the principal copper vein seen by him in the district. The lode, a breccia vein, resembling the Little Plant silver lode, is from 1 to 3 feet wide, strikes 16° N. of E., dips S.E. The vein stuff is chiefly chlorite with a little quartz containing blue and green carbonate of copper. The country is dark thickly-cleaved claystone.

Copper occurrences are also reported at Little Plant Creek, Pye's Creek, Glen Creek, and the Ottery lode. In portion 85, parish Strathbogie North, a vein of cellular quartz about 2 feet (?) wide strikes N. 40° E. The veinstuff shows streaks of blue carbonate and a little black oxide of copper.

In portion 2, parish Paradise North, county Gough, the same authority mentions the occurrence of a vein of fluorspar, copper carbonate, and iron oxide striking 20° N. of E., and dipping northerly. The portion containing the copper carbonate is 4½ inches wide.

Grey copper ore, Tetrahedrite, containing from 400 to 1,100 oz. of silver per ton, occurred in the silver lodes at Little Plant Creek and Pye's Creek.

The following analysis by the Government Analyst shows the composition of the argentiferous grey copper:—

In 100,000 parts.

Metallic copper	31·500
,, antimony	18·130
,, zinc	6·140
,, iron	6·440
,, lead	·680
,, silver	1·635
Sulphur	26·180
Insoluble in acids (silica)	7·200
Traces of arsenic, gold, undetermined	2·095
	100·000

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Kookabookra Division.

Guy Fawkes River, 15 miles N.W. of Hernani; also, 38 miles on road Armidale to Guy Fawkes, and 1½ miles S.E. of 38-mile road peg.—Copper ore in small vein, striking north and south, dip west. Formation, about 2 feet; copper sulphide veins 2 to 3 inches thick. Opened in creek, 9 miles from Guy Fawkes.

Drake Division.

Lady Mary, and Lady Mary Extended Mines, Drake.—Geological-Surveyor E. C. Andrews reported a dyke and quartz reef associated in these claims. The quartz reef strong, but of poor quality; width about 4 feet. The dyke, in places, exceeds 22 feet in width. Small veins of enriched black copper sulphide occur throughout the mass. Two shafts, about 140 feet deep, have been sunk in the dyke. (Ann. Rept., 1903, p. 132.)

In 1907 the main shaft was 170 feet deep, the principal mining being at 120-feet level, where the lode is reported to have a width of 9 feet, and an average value of 4 to 5 per cent. of copper, with rich bunches up to 18 and 20 per cent.

Gross output during 1907, 29 tons; 25½ tons smelted gave 4½ tons of copper at Customs Smelting Works (*ibid.*, 1907).

Of the Lady Mary Extended, portion 180, parish West Fairfield, county Drake, Inspector G. Smith reported in 1905: The strike N. 20° E.; dip easterly. Width, 9 feet. Maximum length of proving, about 100 feet. Depth, 170 feet.

Output—about 20 tons copper ore averaging 27 per cent., 1,200 tons copper ore averaging 3 per cent. The latter concentrated in a local battery to 80 tons, yielding 32 per cent. copper. One hundred and thirty tons from a quartz vein also yielded 230 oz. of gold.

In 1906 a 20-feet eastern crosscut proved a 2-feet vein, worth 5 to 6 per cent. of copper. At 120-feet level a crosscut east for 40 feet, proved a formation, 6 feet wide, containing a 4-inch copper vein, worth 20 per cent.

Value of output for year, £263.

Mount Carrington Mine.—Geological-Surveyor Andrews reported (Ann. Rept., 1903, p. 132) that this lode is similar to the Pioneer, near by, but amount of sulphides less. Deepest shaft, 340 feet, following underlay. Vertical shaft, 200 feet, to intersect reef on east. Average width, from 3 to 4 feet. Worked for copper.

Mount Carrington.—A little copper ore has always been a feature of the auriferous veins and lodes of the Drake District (*see* Drake), and with depth payable copper veins have been opened. Under date 14th, July 1898, Mr. J. P. Curran, Warden's Clerk, Drake, supplied the following particulars of the aspect of the copper-mining industry in his district at that date:—

"Three distinct copper lodes, striking north and south, occur on the north side of Mount Carrington. The ore at surface is of good quality, but operations so far are too shallow to allow of definite determination as to permanency of lodes. The indications, however, are favourable.

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"The lode in Mineral Lease 5, of 40 acres, held by J. Staunton and party, appears well defined, and about 3 feet thick. It has been opened in several places for a distance of about 10 chains, disclosing carbonates of good quality near the surface, and native copper and red oxide just beneath."

In 1893 the following parcels were treated at the English and Australian Smelting Works, Waratah:—

	Yield.
19 tons 9 cwt.	20 per cent. copper.
7 „ 0 „	18 „ „
5 „ 5 „	25 „ „
3 „ 5 „	21 „ „
12 „ 10 „	18½ „ „
5 „ 17 „	19 „ „
3 „ 16 „	21 „ „

In addition, Mr. Curran reports that a large quantity of this ore was treated by the Adeline Company in 1891 at its local works, with very satisfactory results.

A short distance west of Staunton and party's mine, is another parallel lode worked by D. Creed and party in a mineral lease of 20 acres. A shaft had been sunk to 35 feet, at which level a large bunch of red oxide was met. The lode, so far as opened, varies from 9 inches to 3 feet in thickness.

About 12 chains south of Creed and party, and apparently on the same line, Handcock and party are working at a depth of 140 feet on a 6-inch copper vein, composed chiefly of black oxide, assaying from 20 to 40 per cent. of copper. A parcel of 5 tons treated at the English and Australian Smelting Works, Waratah, yielded 25 per cent. of copper and 1 oz. gold per ton.

A short distance further west, D. Mickle and party were working the Great American Barber Mine.

In the adjoining block, on the same line, Hawkins and Tubman, at a depth of 40 feet, were working on a small but rich vein of black oxide, assaying from 30 to 40 per cent. of copper. Considerable improvement in the width of the vein was manifest at the 60-feet level at a later date, the lode being well defined, the matrix quartz, with about 2 feet of clean ore over 30 per cent. grade.

Still further west, Kay and Peacock had opened a promising copper lode on what is regarded as a new line, and at a depth of 15 feet obtained a quantity of black and yellow ore. Two veins occur in the shaft, 9 and 12 inches thick.

The Adeline Mine, which was originally worked for gold, may now be classed as a copper mine, as copper is the predominant metal. At the 100-feet level the lode for a considerable distance along its course varies from 3 to 5 feet in thickness. 16 tons 10 cwt. treated at the Smelting Company of Australia's Works, Dapto, yielded 1 ton 4 cwt. of copper—equivalent to about 7½ per cent.

M.L. 5, parish W. Fairfield, county Drake, about 1 mile north of village of Fairfield.—Inspector G. Smith reported (P.B. $\frac{2}{0}\frac{2}{5}\frac{2}{2}$) copper lode in igneous (?) rock. Said to have averaged 5 per cent. of copper, and 2 dwt. of gold per ton. Average thickness, 2 ft. 6 in.

Aided to sink a further depth of 60 feet.

Pioneer Mine, Drake.—Geological-Surveyor E. C. Andrews describes three shafts on this lode, deepest 240 feet, following underlay. Lode well

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defined, averaging 18 to 24 inches in width. Ores copper and gold; copper ore as black oxides, and yellow sulphide. Reported to average 4 to 5 per cent. of the vein. Gangue-quartz, with sulphides of iron, varying from 20 to 40 per cent. Underlay, 1 in 1. (Ann. Rept., 1903, p. 132.)

In 1907 a tunnel had been driven 800 feet. Lode formation, 3½ feet wide, from which 425 tons crude ore were obtained, which produced 14½ tons of copper (*ibid.*, 1907).

Poor Man's Friend Mine, Drake.—Two shafts on line of lode, 30 and 40 feet, connected by level 140 feet long. Width, 6 to 12 inches. About 34 tons smelted at Customs Works for 4 tons 17 cwt. of copper.

Deepwater Division.

Pye's Creek, 14 miles N.N.W. of Deepwater, and 1 mile from Cadell's out station on Pye's Creek.—A lode about 4 feet thick is reported to occur at the above locality, consisting of copper and iron pyrites, galena, and zinc-blende. Bunches of rich copper ores occur at intervals. Opened about 40 feet by shaft, and driven on for 20 feet. About 40 tons of mixed ore at grass. No bulk tests made. Assays yielded up to 20 per cent. of copper from best bunches. Numerous indications are reported to occur in neighbouring veins and lodes.

Drake Division.

Rainbow Mine, portion 188, parish West Fairfield, county Drake.—Inspector G. Smith reported (1/7/05): Quartz vein with gold and copper ores, striking N.E., and dipping S.E. Proved to 140 feet, and for a length of 150 feet.

Gross output, 300 tons of ore, valued at £3,000.

In 1906 Parker and party put in tunnel to unwater old workings, and intersect lode at 180 feet. Cut another lode at 150 feet, striking at an acute angle to the Rainbow. New lode, 2 feet wide, containing low grade concentrating ore, and bunches of native copper.

Thirty-one tons ore sent to smelting works realised £105. (Ann. Rept. 1906, p. 48.)

Hillgrove Division.

Sunnyside Copper and Silver Mine.—See p. 330.

Styx River, 35 miles from Armidale, and 9 from George's Creek.—Formation 2 feet wide, with poor copper ore. Showing also in river about 2 chains above bridge. Tunnel driven 60 feet.

Ward's Mistake, C. E. Brazier's claim, parish Blythe, county Clarke.—Inspector J. James reported (P.B. $\frac{21}{0}\frac{6}{7}\frac{8}{8}$) a copper lode in sandstone and slate. Carbonates discovered at surface, and traced for upwards of 100 feet in length. About 6 inches of sulphides showing at bottom of shaft. Aided to sink to 72 feet.

Progress.—At 47 feet a small bunch of ore encountered, not payable. At 64 feet progress slow on account of water. A fair deposit of copper ore visible, but insufficient to pay for working. Aid for tunnel refused.

McKinley's Claim, 9 miles east of Ward's Mistake, same parish, about quarter mile east of Brazier's claim.—Inspector J. James reported (P.B. $\frac{21}{0}\frac{8}{7}\frac{8}{8}$) gossany formation in sandstone and slate. Formation, 20 to 40 feet wide, with gossan outcropping in several places. Aid granted to sink to 50 feet.

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Progress.—At 35 feet, occasional pieces of quartz with copper ore. At 50 feet, ironstone bands.

Re-examined by Inspector James (P.B. $\frac{2}{0}\frac{2}{6}\frac{7}{6}$), who reported that lode had been passed through. Aid granted to crosscut.

Emmaville Division.

Willow's Mine, north side of Glen Creek, 4 miles from Tent Hill, 6 miles from Emmaville, and 18 from the Deepwater Railway Station.—This mine occurs between the Little Plant Silver Mine and the Emerald Mine. The lode in it varies from 8 inches to 3 ft. 6 in. in thickness, and is about 12 inches at the lowest level reached—70 feet.

5¼ tons yielded about 5½ per cent. of copper at the Smelting Company of Australia's Works, Dapto.

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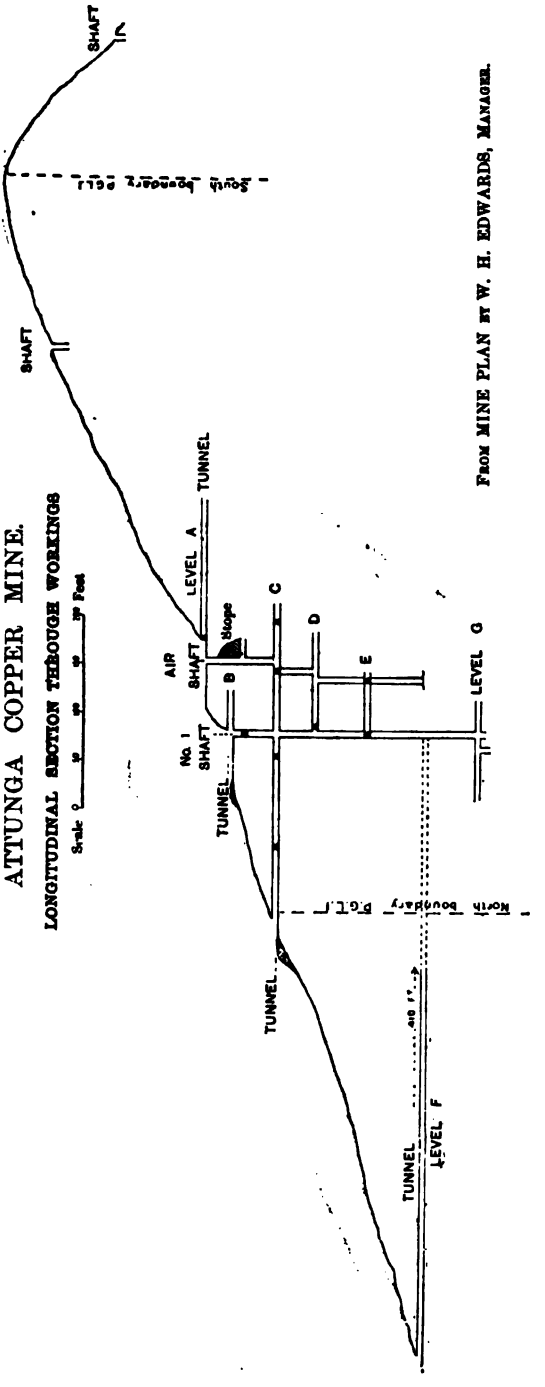
Attunga Copper Mine, P.M.Ls. 1 and 2, and P.G.L. 1; areas, 10, 5; and 14 acres; within portions 225 and 226, parish Attunga, county Inglis, in T. Bryan's land; 9 miles easterly from Attunga Railway Station.—Discovered and taken up by J. Brogan in 1902, but probably known to the owner of the land prior to that date.

The Attunga lodes strikes about north and south at contact of limestone and sedimentary rocks with igneous. The outcrop for the greater part of its length has determined a small gully owing to its greater susceptibility to weathering. The latter falls into Willow Tree Creek, one of the heads of Attunga Creek. At no great distance below the mine is a permanent water supply. Within half a mile an excellent dam site is obtainable.

In the accompanying longitudinal section of the workings it will be observed that the southern termination of the outcrop rises to the top of a saddle 400 feet above the lowest tunnel (F); on either side of the latter, ranges rise above it 1,000 to 1,200 feet.

South of the saddle the main lode has not yet been proved to extend, though a cross lode striking N. 85° W. has been discovered on the southern fall. It



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occurs in an igneous rock (andesite), has no true walls, being fast or "frozen" in the solid country. Small nodules of rich sulphide (bornite) occur, but are not persistent, the greatest width of ore being about 12 inches. The average quality is shown in Assay No. 08–1196.

Though the main lode is traceable by workings and open cuts for about 900 feet, actual mining is confined to a length of about 220 feet, and a depth of 258 feet, though little actual stoping has taken place. Sulphides begin about 30 feet above the lowest or G level—which marks the water-level; their quality is shown in Assays 08–1194 and 1195.

As might be expected in a contact deposit, where partial alteration of one rock (limestone) has given rise to the secondary mineral garnet, the width of mineralisation is variable, ranging from a couple of feet to over 20 feet; in some bunches to 60 feet; though these greater measurements include barren bands.

Assay No.	Description.	Copper, per cent.	Iron,‡ per cent.	Silica, per cent.	Sulphur, per cent.	Alumina,§ per cent.	Bismuth, per cent.	Gold, per ton.	Silver, per ton.
							less than	oz. dwt. grs.	oz. dwt. grs.
08-1190	Average of paddocks of "firsts" from A and B levels.	6·20	6·23	38·01	...	8·26	0·25	0 4 8	4 15 19
08-1191	Average of paddocks of "seconds" from A and B levels.	5·22	5·82	38·70	..	9·50	0·25	0 3 6	3 2 1
08-1192	Average of "firsts" from 2-feet wide E. level.	9·85	5·81	36·03	..	1·86*	0·25	0 6 13	6 4 3
08-1193	Average of "seconds" from 2-feet wide E. level.	1·87	5·88	41·16	..	2·86	0·25	0 2 4	0 13 1
08-1194	Average of ore from G level, 5 feet wide.	3·28	5·46	39·77	0·06	1·56	0·25	0 10 21	3 18 9
08-1195	†Average of ore from G level, south end, 3 feet wide.	0·56	2·59	33·53	2·38	8·04	Nil....	0 4 8	0 8 17
08-1196	Average of cross lode, south end of lease.	14·92						0 10 21	10 13 10

* Phosphoric acid, 0·70 per cent. † Contains a fair quantity of Molybdenite. ‡ Soluble in acid.
§ Including a little phosphoric acid.

NOTE.—In each case the gangue—in addition to the silica and alumina determined—contains large quantities of lime, some magnesia, and a little iron which was not determined. All the samples contain more or less carbon dioxide and water. The copper is present as oxide or carbonate. The iron (soluble in acid) is present as oxide or carbonate. The percentage of alumina represents the total alumina.

Taking sample No. 08–1190 for example, the assay results can be stated thus:—

Copper	6·20	per cent.
Iron	6·23	,,
Sulphur	nil.	
Silica	38·01	,,
Bismuth	less than 0·25	,,
Alumina and a little phosphoric acid	8·26	,,
Oxygen, carbon dioxide, lime, magnesia, water, &c.	41·30	,,
	100·00	

The non-metallic gangue, therefore, works out in each case as follows:—

No. 1190, 68·43 per cent.; No. 1191, 56·21 per cent.; No. 1194, 44·47 per cent.; No. 1193, 65·9 per cent.; No. 1194, 70·49 per cent.; No. 1195, 77·91 per cent.

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An earlier sample of the carbonate ore yielded:—

No. 05-3128—	Silica (SiO_2)	34·32
	Alumina (Al_2O_3)	12·64
	Ferric oxide (Fe_2O_3)	9·50
	Copper oxide (CuO)	8·45
	Bismuth (Bi)	0·17
	Lime (CaO)	7·92
	Magnesia (MgO)	1·44
	Manganese (Mn)	0·25
	Ferrous oxide (FeO)	trace

A sample of the limestone from lowest tunnel (F level), which occurs on the western wall of the lode, yielded the following composition on partial analysis, the impurity of which is doubtless due to secondary silicic infiltration from the ore channel:—

No. 08-1204—	Calcium carbonate ($CaCO_3$)	75·77
	Lime (CaO)	2·65
	Ferric oxide and alumina ($Fe_2O_3+Al_2O_3$)	3·74
	Magnesium carbonate ($MgCO_3$) and undetermined	0·14
	Gangue	17·70
		100·00

NOTE.—Gangue mainly silica with some earthy matter. A few specks of pyrites visible. A portion of lime is combined as silicate, as there is not sufficient carbon dioxide present to combine with the total lime.

Abundance of excellent limestone is, however, procurable within a few chains.

A yellowish-green silicate of iron is conspicuous in parts of the lode channel, the composition of which is shown in the following analysis:—

No. 05-2175—	Moisture at 100° C.	4·50
	Water above 100° C.	4·84
	Silica	73·26
	Alumina	0·50
	Ferric oxide	14·90
	Ferrous oxide	0·27
	Manganous oxide	0·01
	Lime	1·22
	Magnesia	0·24
	Barium oxide	absent.
	Strontium oxide	trace.
	Soda	0·28
	Potash	0·13
	Lithia	absent.
	Phosphoric acid	trace.
	Titanic acid	absent.
	Vanadic oxide	,,
	Chlorine	,,
	Copper oxide	0·12
		100·27

Specific gravity, 2·243.

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PEEL AND URALLA MINING DISTRICT—*continued*.

Output.—The output for which account sales have been received is shown in the following table. About 946 tons were sent from the mine, some of which remains unsold. Remarkable discrepancies, however, occur between the mine weights and actual returns.

Location.	Quantity (21 cwt. tons).	Copper, per cent.		Gold, per ton.		Silver, per ton.	
		From	To	From	To	From	To
	tons cwt. qr.			dwt.	dwt.	oz. dwt. gr.	oz. dwt. gr.
Open cut, mouth of A tunnel....	404 0 0	5·5	6·78	3·1	9·14	4 18 5	6 0 0
Open cut and B tunnel	152 13 0	5·2	6·7	4	4·9	4 0 0	5 6 0
C level and stopes	118 5 3	5·6	8·78	3½	4	4 0 0	4 3 14

Total, 674 tons 18 cwt. 3 qrs., or 708·6 ordinary tons.

The total amount despatched from the mine, according to the manager's estimates, was 946 tons 2 cwt. 2 qrs., without allowance for moisture.

The appreciable quantities of gold and silver revealed in the above returns from Customs Smelting Works, and in the assays of very carefully taken samples of many tons of ore at grass, made in the Departmental Laboratory, are of special importance in the economics of this mine, especially when it is known that the noble metals are not confined to the copper ores. Probably a proportion of the non-cupriferous lodestuff may prove payably amenable to cyanidation.

Dr. R. L. Jack, who made a prolonged and exhaustive examination of the mine just prior to the Writer's visit, estimates the ore at grass—by measurement—at 1,628 tons.

The following assay returns, from average samples, personally selected by Dr. Jack from ore faces in different portions of the workings, are taken from his report:—

Portion of Mine.	Width of Ore.	Nature of Ore.	Copper, per cent.
	ft. in.		
A Level	3 0	Carbonate	13 4
,, ...	1 0	,, in garnet	8·6
B Level	3 5	Carbonate	12·5
,, (below)	5 0	,, ...	7·5
,, ,, ...	2 0	,, ...	21·0
C Level	3 2	,, ...	2 4
,, ...	5 10	,, ...	2·4
,, ...	1 3	,, ...	1·8
,, ...	6 0	,, ...	4·3
,, ...	3 0	,, ...	2·8
,, ...	4 0	,, ...	5·4
,, ...	1 0	,, ...	2·8
,, ...	10 0	,, ...	5·3
D Level	2 0	,, ...	5·2
,, ...	4 3	,, ...	4·3
,, ...	3 6	,, ...	3·2
G Level, winze	0 3	Sulphides	1·5
,, ,, ...	1 0	,, (west side).....	11·9
O Shaft, near top of saddle	0 9	Carbonates	·4
South side (cross lode)	1 3	.....	7·8

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"G" level, which marks approximately water-level, is 75 feet below the lowest feasible tunnel-level (F), which is now being driven for the purpose of reducing the water lift, and thus facilitating deeper sinking to prove the sulphide zone below water-level. On the extent and quality of the latter, the future prospects of the mine—as a copper producer—depend. From the absence of solid pyritic masses, so far as proved, concentration will probably have to be faced.

Here a note of warning is offered in reference to contemplated establishment of blast furnace reduction for the oxidised ores (which applies with equal force to ordinary reverberatory furnacing). Attempting to smelt silicious oxidised ores in the absence of sulphides would result in too rapid reduction, and unclean slags. Moreover, the productive furnace capacity would be proportionally lessened by the large necessary admixture of probably valueless fluxes.

The wisdom, therefore, of proving the sulphide resources of the lode before devising, or even contemplating a reduction plant, is unquestionable.

Barraba Division.

Barraba District, 12 miles N.E. of Barraba, and 7 miles S.W. of Gulf Creek Copper Mine, parish Tiabundie, county Darling.—Inspector Carthew reported quartz reef in sandstone. Strike E. and W.; dip S.; shaft, 46 feet.

Aided to 146-feet level. At 81 feet serpentine rock met, carrying copper and iron, reef 6 inches thick. Country hard; water making. Similar conditions at 102 feet. Abandoned.

Bingara Division.

Bingara District.—Inspector Carthew, in 1901, reported—A quartz reef containing copper ore 7 miles south-easterly from Bingara, near Gwydir River, towards Keira Station. About 30 chains south of M.L. 11, parish Bingara, county Murchison. Strike of reef N. and S. Aided to sink 100 feet; aid not availed of.

Also a quartz reef with copper and gold in altered slates at Spring Creek, 3½ miles south-east of Bingara. Strike N. and S.; dip E. Shafts, 15 feet and 35 feet. Aided to sink to 135 feet. (P.B. $\frac{1}{0}\frac{s}{0}\frac{s}{0}$.)

Progress.—At 53 feet, serpentine rock with indications of copper. At 68 feet, several small veins showing in shaft. No further record.

Bobby Whitlow Mine, M.L. 3, parish Myall, county Murchison; about 7 miles from Bingara, and 27 by road from Warialda Railway Station.—Discovered by R. Bennett and F. Clusterman about 1875. Worked intermittently. Ore raised and despatched to end of 1906—about 802 tons, averaging from 8 to 16 per cent. of copper. No seconds.

Examined August, 1907. Lode strikes N. 10° E.; dips east slightly. Country slate with quartzite bands.

Opened by two shafts 30 feet apart, to depths of 82 feet and 142 feet respectively. Water-level at 120 feet. Oxidised ores to about 85 feet; enriched sulphides stoped to 95 feet, little stoping below this level. Not open to inspection below 120 feet. Unaltered sulphide apparently too low grade for despatch.

Greatest length of lens in oxidised zone about 85 feet; 55 feet in enriched sulphide, apparently contracting with depth. Width, 1 to 7 feet.

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No prospecting beyond ends of ore body though channel persists. At 82-feet level a 19-feet lens proved after blank of 10 feet. No crosscutting, though a flat vein enters footwall at about 70 feet. Parallel vein splitting from main lens on east side at 82-feet level followed down until pinched; 70 tons ore extracted from it; channel still persistent.

Option secured by Messrs. Brandeis, Goldschmidt, & Co. in 1907. After cleaning out the shaft the prospects were not considered encouraging enough for further development; the option was therefore abandoned.

Bora Creek Copper Mine, M.L. 5, parish Bingara, county Murchison; about 7 miles from Bingara, on south side of Gwydir River, near Bundarra road.—Strike N.W. in slate; dip S.W. at 71°. Shaft sunk many years ago, to about 40 feet, and a few tons of copper ore extracted.

Aided (P.B. $\frac{11}{0}\frac{5}{6}\frac{2}{}$) to sink from 40 to 100 feet.

At 80 feet shaft following veins of copper ore. At 86 feet water making, with thin veins of enriched (black) sulphide showing.

Position in August, 1907.—At 40-feet level in underlay shaft, driven 20 feet south-east. Winze from this point 30 feet deep; reported on ore.

Channel 2 ft. 6 in. to 3 feet wide, filled with gossan. Vertical shaft 20 feet south-west of underlay shaft—cut reef at 80 feet. Driven 40 feet south-east on sulphide ore, which pinched at end of drive, but passed under foot. Country slate and jasperoid quartzite.

Thirty tons of sulphides from vertical shaft and south-east drive yielded $6\frac{3}{4}$ to 8 per cent. of copper. Seven tons bagged at surface; close picking should bring grade to at least 10 per cent.

Nundle Division.

Bowling Alley Point, 3 miles from and 1 mile east of road to Nundle, parish Dungowan, county Parry.—Inspector James reported (P.B. $\frac{2}{0}\frac{7}{7}\frac{2}{}\frac{1}{}$) lode formation carrying copper in diorite and slate. Sunk on to 30 feet; showing a small vein 4 to 6 inches wide, carrying blue and green carbonates. Sinking expensive, owing to water making.

Aided to tunnel from 63 feet to 104 feet along the lode.

Armidale Division.

Bundarra Mine, parish Darby, county Hardinge; 3 miles south of Bundarra, 1 mile from Gwydir River, and 32 from Inverell Railway Station.—Discovered by H. Shand about 1877. Opened by J. Russell and party about 1897, and proved to 150 feet. Rich patches of ore obtained, but no defined or continuous lode. Seventy-two tons of ore despatched to August, 1898, averaging about 17 per cent. copper.

Three hundred feet level reached in 1900; thence until 1906 practically idle. Passed into possession of Messrs. Brandeis, Goldschmidt, & Co., London, at end of 1905. Small reverberatory furnace erected.

Examined March, 1907.—Strike N. and S.; dip west at 45°. Country altered slate (chloritic) and jasperoid quartzite. Main ore-body proved 18 feet to 22 feet long. The 124-feet, 200-feet, and 270-feet levels extended from 40 feet to 140 feet north and south beyond the ore shoot in blank

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channel rock. Payable ore exhausted above 270-feet level; below it, winze sunk in low grade ore to 360-feet level. Average sample from it gave the following results:—

No. 07-6436—Copper	0·90	per cent.	
Zinc	11·04	,,	
Iron	34·74	,,	chiefly magnetic and arsenical pyrites.
Sulphur	9·87	,,	
Silica	14·44	,,	
Gold	A trace (under 2 dwt.) per ton.		
Silver	5 dwt. 10 grs. per ton.		

From surface to 50 feet earthy carbonates occurred, worth about 2½ per cent. copper; from 50 feet to 90 feet, ferruginous carbonates and grey ore, worth about 15 per cent. Average value of ore extracted, about 6 per cent. Zinc-blende prominent in part; also arsenic at lowest level. Calcite, in bands and seams, aids reduction.

Smelting.—In small reverberatory, capacity about 120 tons of ore per week, charging every four hours:—

2½ tons roasted and raw ore, 6 cwt. silica (jasperoid quartzite from mine), ½ to 1 barrow slag (from first three pigs) = 6 cwt. carbonates, ferruginous, 6 cwt. carbonates, earthy, 1 ton 18 cwt. roasted sulphides.

Matte previously shipped at 45 per cent. Recently run to 60 per cent. in finishing up prior to closing down. A barrowful each of charcoal and wood chips added to charge for higher grade.

About 200 tons of heap-roasted ore at grass to finish; absence of compact sulphides renders reduction of oxidised ores too rapid. No flux other than silica used.

The recent mining and smelting campaign has been profitable, but outlook not encouraging enough to induce further effort. Ore at bottom of proved area too poor for extraction. None in sight above water-level. Prospecting has been extended some little distance beyond the ore lens at different levels on north and south strike without avail. Other lenses may occur in crushed channel, but prospecting may be costly. The latter pinches very thin in places, and is thrown to the west. Greatest width in ore lens about 7 feet.

Owners relinquishing mine and dismantling plant.

The total output during the last smelting campaign—between 12th February, 1906, and 10th September, 1907—amounted to 3,732 tons of ore, producing 418 tons of matte.

Towards the end of the latter year, preparations for re-opening were being made by others.

Copeland Division.

Comstock Copper Mine (formerly Wet Creek); on F. Williams' C.L., parish Dewitt, county Hawes; about 25 miles from Copeland.—Inspector D. Milne reported (P.B. $\frac{18}{04}\frac{11}{1}$) a lode formation heavily stained with copper carbonates, also containing small nodules of cuprite in porphyry.

Aid granted for tunnelling 50 feet in the formation.

Progress.—At 24 feet the lode was reported to be 2 ft. 6 in. wide; ore from it reported to assay 11 per cent. copper. Lode later reported to have pinched or dipped. Transfer of aid to shaft refused; balance cancelled on account of work ceasing.

Property secured by a Newcastle syndicate. Re-inspected by Mr. Milne (P.B. $\frac{18}{07}\frac{4}{1}\frac{5}{5}$).

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Aid granted to continue tunnel on north side of creek from 40 feet to 190 feet, following the formation. Inspector Milne reported:—"On the site where the tunnel is started immense blocks of gossan are lying on the surface, and the tunnel is driven (40 feet) in ore. All the surface indications point to the hill being the strongest portion of the lode." In the shaft for which aid was refused, on the opposite side of the creek, the formation is described as very broken, and assay results very erratic, and not so favourable as in tunnel.

Tingha Division.

Conrad Stannite Mines, Ltd., Borah Creek, parish Mayo, county Hardinge.—In granite country. The feature of this lode is its great horizontal persistence in undiminished strength; the provings extending over 6,000 feet, and worked continuously for 4,611 feet. To quote the manager—Mr. B. C. Besley—"We have worked, at a depth, 4,611 feet continuously, and during that length of lode we have only had one fault—these workings run from 400 to 500 feet deep on the average. The fault was at the 400-feet level, and was a complete cut off in the lode for 30 feet, and is very interesting as it was so clean and complete, and was taken up at exactly the same width as where it first left the lode.

"With reference to the proved distance of the lode, a shaft has been sunk over 6,000 feet south of this again, for over 130 feet in the same lode; which is easily traced along the surface.

"Another peculiar point about this lode is that exactly the same ore is found on the surface as at a depth of 900 feet underground. Under the Big Hill it is now 900 feet to our bottom workings."

The composition of the ore is best judged from the following returns, furnished by the manager, from January to September, 1907:—

1,970 tons lead concentrates; average assay value,—lead 45 per cent., silver 80 oz. per ton.
570 tons prill ore, assaying about 60 per cent. lead and 120 oz. silver per ton.
260 tons copper matte, averaging about 40 per cent. copper and 250 to 400 oz. silver per ton.
A tin-lead bullion is also being turned out, containing about 45 per cent. of tin, the balance being lead.

Method of treatment.—Concentrating in mill producing lead concentrates as above, and tin sulphide concentrates, the latter being treated on the mine.

Process.—Calcination in a Merton calciner down to about 6 per cent. sulphur, roasted ore smelted in reverberatory, precipitating tin into slag, and producing matte of about 40 per cent. copper in one operation.

Slag, containing about 10 per cent. tin, is melted, and tin precipitated by using green poles and metallic iron, leaving about 2 per cent. of tin in slag. (Process discovered by Mr. J. Howell.)

Walcha Division.

Cooperacurripa Copper Mine, near Nowendoc.—Lode in main shaft reported to be 4 ft. 6 in. thick at 45 feet, and the ore improving from 8 to 14 per cent. Another shaft on a reported 14-feet lode of promising character.

Tingha Division.

Cope's Creek.—Near the junction of the Gwydir River and Cope's Creek a sample of lodestuff carrying galena, malachite, and sulphides of iron and copper yielded ($\frac{28}{30}$) 7·08 per cent. of copper, and 59·69 per cent. of lead.

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PEEL AND URALLA MINING DISTRICT—*continued*.

In the *Australian Mining Standard* of the 6th May, 1897, it was announced that a copper lode was discovered near Boggy Camp Diamond Mines, showing carbonates at surface.

Nundle Division.

Dungowan.—Inspector G. Smith reported (P.B. $\frac{20}{0}\frac{12}{4}$) a quartz and ironstone formation 1 to 2 feet thick, with a little copper ore. A sample assaying 3 per cent. of copper, 3 oz. silver, and 2 dwt. gold.

Aided to sink to 60-feet level—at 15 feet reported that copper pinched out.

Walcha Division.

Europambella Lode, near Walcha.—J. Notley and party reported disposing of 110 tons of ore for a gross return of £600, in 1902. Ore reported to average 10 per cent. Deepest shaft, 96 feet. Lode faulted at this level. (Ann. Rept. 1902, p. 49.)

In 1906 Inspector D. Milne reported that the mine had been re-opened. Some tons of ore gathered from surface had yielded about 5 per cent. copper. Lode about 2 feet wide, of an average grade of 2½ per cent. The flow of underground water is heavy (*ibid.*, 1906).

Nundle Division.

Fisher's Copper Mine, Dungowan Creek, about 16 miles from Tamworth, in county Parry; discovered in 1881.

In 1885, Mr. C. S. Wilkinson reported that "lower down Dungowan Creek, on Mr. Fisher's land, some copper-bearing lodes have been opened in places for a length of about 8 chains, striking N. 10° W., and dipping westerly at 70°. These consist of several masses—of irregular size up to 10 feet long and 4 feet wide, and thinning out—of gossan and quartz, containing pyrites, native copper, red oxide, and carbonate of copper. They occur in greenish schists and jasperoid rocks. At the present low price of copper these small bunchy lodes could not be profitably worked."

Under date 19th July, 1898, Mr. Warden Jones writes that this mine, consisting of two mineral purchases of 40 and 50 acres, in 1882 was leased to the Hon. P. G. King, M.L.C., and others, for a period of fourteen years, but little work was done during the tenure of the lease, which expired in 1896. In that year Dr. Pratt secured the right to lease or purchase for a period of two years, which has just expired without labour being expended on the property.

The following assay was made in 1897 of a sample of green carbonate in ferruginous silicious gangue:—Copper, 42·20 per cent; silver, 2 oz. 19 dwt. 21 grs. per ton; gold, a trace (under 2 dwt.). Another sample of carbonate ore, selected by the Warden and forwarded with his letter of the date quoted, yielded copper, 34·23 per cent.; gold, 2 dwt. 4 grs.; and silver, 1 oz. 8 dwt. 7 grs. per ton.

According to the *Australian Mining Standard*, 23rd March, 1899, Mr. Fisher had just received returns of 5 tons 13 cwt. 2 qrs. of copper ore from the lode, which he was opening on his own account, viz., 1 ton 3 cwt. 2 qrs. 1 lb. of copper; value, £83 14s. 4d. A further consignment of 6 tons yielded 1 ton 2 cwt. 25 lb. of copper, which realised £107 13s. 3d.

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Barraba Division.

Four-mile Lode, 4 miles from Gulf Creek, along Wood's Reef road.—Prospecting area. Shaft, 50 feet. Carbonate ore showing on surface, none in shaft. Samples assay about 3 per cent. of copper.

Gulf Creek Copper Mine (originally the *Cornish* Mine), M.Ls. 6 and 7, parish Capel, county Murchison, about 22 miles from Barraba Railway Station; 234 miles by rail from the coast at Newcastle, and 338 from Sydney.

In 1896 the Cornish Company received aid from the Prospecting Vote, by means of which they succeeded in opening up payable ore, which realised sufficient to cover costs of development.

In the beginning of 1898 the mine was let on tribute, and later in the year passed into the possession of the Mining and Financial Trust Syndicate, Limited.

From the report of the Secretary of the Cornish Company, it appears that the first campaign only lasted until October, 1896, during which a reverberatory and a small blast furnace were erected. In the former 800 tons of ore were smelted, and about 200 in the latter, with, however, unsatisfactory results.

Three parallel lodes are now known, but the first company was only aware of one—the East lode.

In 1899 the mine was secured by W. H. Trewenack, who ran it on his own account for a few months, and then on behalf of an English company (The Gulf Creek), this campaign lasting until 1905. Smelting was carried on for a part of the time (1903 to 1905) in two reverberatories, and a small blast furnace. Later on a 40-ton blast furnace was added to the plant.

According to Mr. Trewenack, about 1,200 tons of ore per month were smelted for an average yield of about 5 per cent. of copper, the resulting matte being shipped to Swansea.

On depreciation of ore tenor the mine was abandoned by the Gulf Creek Company in 1895, but was immediately secured by some of the late employees, under the title of the Gulf Creek Syndicate, who ran it until February, 1907, when it was purchased by the present owners, Messrs. Brandeis, Goldschmidt & Co., London.

During the Gulf Syndicate's campaign about 200 tons of ore per month were reduced in one reverberatory furnace, for an average yield of about 6 per cent., and a matte grade of 40.

From a "burnt" stope, about 500 tons of naturally reduced matte was disposed of by the Syndicate for yields averaging from 12 to 20 per cent. copper. About 20 tons of washed material yielding from 45 to 60 per cent.

Messrs. Brandeis, Goldschmidt & Co. began operations on 1st May, 1907, renovating and rebuilding plant, developing and prospecting the lodes.

According to Mr. R. Schloesser, Supervising Engineer, whilst high metal values prevailed, about 2,500 tons of ore were smelted in the two reverberatories for 269 tons of matte of about 35 to 36 grade; which was shipped to England.

This amount brings the total output of ore from the mine, so far as records can be obtained, to between 34,000 and 37,000 tons to the end of 1907.

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H. Stewart.

Gulf Creek Copper Mine, near Barraba.

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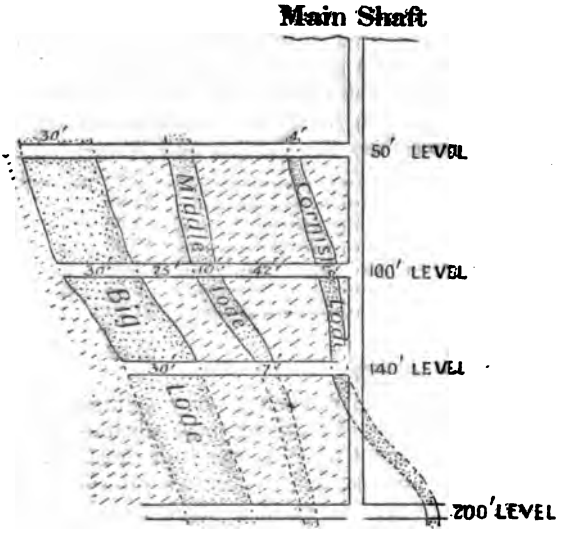
Under the new ownership the mine has been completely equipped with tools, hauling appliances, tramways, &c.; the main shaft is being deepened, and a 100-ton blast furnace erected for treatment of the large bodies of low-grade pyritic ore already revealed.

The three lodes proved in the mine are:—

No. 1 ... Cornish, or East Lode.
No. 2 ... Middle Lode.
No. 3 ... Big Lode.

They are, approximately, parallel, striking about N. 50° W. The dips are to N. 40° E., but vary in amount, which brings them closer in depth.

The following cross section illustrates their mode of occurrence, thickness, and inclination:—



On the north-western strike, beyond the main lens worked in the Cornish lode, two others were found and worked.

On No. 1 level, 330 feet beyond the end of the Cornish main lens, a smaller lens was driven on for 80 feet; and on No. 2 level for a distance of 35 feet.

Similar short lenses have evidently been potholed where gossan outcrops appeared at surface.

On the south-eastern strike of the Cornish lode, a level was continued for a long distance beyond the main lens without encountering others, the total length driven along the strike of this lode being 1,140 feet.

The big lode has been proved by crosscuts at the No. 2 level to have a thickness of 38 to 40 feet, and an average copper value of between 2 and 3 per cent.

The upper portion of this pyritic lode caught fire at the No. 1 level (50 feet) through exposure, by the earlier workings, of the zone of decomposition.

Analagous occurrences of sulphides chemically firing—by oxidation—are the "brassy top" fires of the Upper Greta coal-seam, and the pyritic lode-stuff of the Federal Mine, near Frogmore.

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The fire started during Trewenack's campaign, at a crosscut end from main shaft, and extended 250 feet along the south-east strike, and burned upwards to the gossan, and downwards for about 20 feet below the level.

Attempts were made to smother and extinguish by water and steam, and sealing, but unavailingly. Shafts were also sunk from surface to get at seat of firing.

The fire burned out after abandonment, ceasing about 1905, after the Gulf Syndicate assumed possession. The latter opened up the workings to allow free access of air and accelerate combustion.

In working the burnt stope—from which 500 tons of naturally reduced matte were obtained—spraying and respirators were used for protection against fine acidic ash.

The fire evidently ceased just below the zone of enrichment, for the unburned pyritic lodestuff has an average value of under 3 per cent.

The present proprietary used a proportion of the remaining burnt ore (averaging about 4½ per cent.) in their furnace charges.

The composition of Gulf Creek sulphide ore may be studied in the following average analysis of 1,330 tons from No. 2 level (100 feet), 1,000 from the big lode, and the balance from the Cornish and Middle lodes:—

Copper	2·7	per cent.
Iron	31·85	,,
Zinc	4·65	,,
Silica	18·93	,,
Alumina	4·84	,,
Lime	2·95	,,
Sulphur	31·70	,,
	97·62	

Gold and silver inappreciable.

The composition of this ore renders it very suitable for partial pyritic smelting, and affords a means of reducing more silicious ores.

Smelting plant.—The original plant of the Gulf Creek Company embraced a calciner furnace, blast furnace, and two reverberatories. The calciner and blast furnace were removed; the calciner stack remaining is 45 feet high, and the reverberatory stack, 120 feet. The flue connections remaining of the blast furnace equipment, measure 450 feet, part on piers, part under ground, the section being 6 feet x 8 feet.

Pending erection of a 100-ton blast furnace, the present owners have utilised the existing reverberatory. The furnace charge being:—

19,124 lb. roasted (heap) sulphide ore.
11,760 ,, burnt stope ore and raw ore (as required).
2,000 ,, old bricks from bottoms, re-treated slags, and quartzite.

32,884 lb. charged every four hours.

As ore is basic, one-fifteenth of silica is added in the form of quartzite.

The composition of the resultant slag is shown in the following analysis by Mr. Gurney:—

Copper	0·67
Iron	52·37
Zinc	2·4
Silica	32·2
Alumina	7·5
Lime	4·39
	99·53

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H. Stewart. **Gulf Creek Smelting Works, Offices, &c., near Barraba.**

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PEEL AND URALLA MINING DISTRICT—*continued.*

Limestone used for fluxing is obtained from portion 16, parish Capel, about 140 chains N.W. of the mine. Its composition is revealed in the following partial analysis:—

No. 07-6434—Carbonate of lime	92·35	per cent.
Carbonate of magnesia and undetermined	0·37	,,
Ferric oxide and alumina	1·60	,,
Gangue	5·68	,,
	100·00	

The composition of the local clay, which is used with a percentage of sand from Macintyre Creek for fettling is:—

No. 07-6437—Water (at 100° C.)	0·67	per cent.
Water (above 100° C.)	7·33	,,
Silica	64·35	,,
Alumina	16·58	,,
Ferric oxide	7·40	,,
Ferrous oxide	0·27	,,
Lime	0·50	,,
Magnesia	0·21	,,
Potash	0·80	,,
Soda	0·83	,,
Titanic acid (TiO_2)	0·70	,,
Phosphoric acid (P_2O_5)	0·07	,,
	99·71	

A trace of chlorine (soluble) and sulphuric anhydride detected.

Macintyre Creek sand—distant about 6 to 8 miles—used also for moulding, contains 83·7 per cent. of silica.

Newcastle beach sand is used for furnace bottoms.

The sulphides are roasted in clamps of about 250 tons—about eight weeks being occupied in the process.

The "burnt stope" ore has been reduced to about 18 per cent. of sulphur.

Copper in Mine Water.—During baling operations about 20,000 gallons per day were lifted. From the rate of reduction it is probable that the permanent daily make of water does not exceed 8,000 or 10,000 gallons.

The accumulated water in the workings was found by frequent tests to hold 0·09 per cent. of copper in solution; and after passage through the precipitating vats, 0·03 per cent.: an extraction of 66 per cent., which is good considering the rapidity of the flow and the solidity of the scrap iron in use.

About 3½ tons of cement copper obtained in partial clean-ups to September, 1907, contained about 73 per cent. of copper, the balance being ferric oxide.

An interesting fact, noted by the principal vat boy—E. Kenny—was that coke, or raw pyritic ore, acted as a cathode in the solution when in contact with iron, but remained inert without it. Mr. Schloesser, writing in January, 1908, stated that precipitation is now effected by layers of coke and heavy iron as more economical. The copper being precipitated in the presence of iron on the surface of the coke, which is broken to about 3-inch gauge. Fresh coke being introduced from time to time, and the copper-bearing coke stacked for use as fuel in the blast furnace.

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Gulf Creek, 1½ miles S.E. of the Gulf Creek Mine, in parish Capel, county Murchison.—Aid was granted to sink 50 feet. Carbonate of copper stains occurred at 20 feet, but no defined lode had been proved to 24 feet (P.B. $\frac{12}{0}\frac{2}{7}\frac{0}{0}$).

Bingara Division.

Harrison's Mine, Copper Gully, Upper Bingara.—Discovered and opened by W. H. Harrison in 1895, in slate and diorite (?) country near serpentine. Lode cut in shaft at 9 feet; thickness, 4 feet; assay value, (2½ per cent. Shaft sunk 35 feet, partly under aid; lode widened to 6 ft. 6 in., and increased in value.

Hilda May Copper Lode, Spring Creek, 3 miles from Bingara.—Originally worked for gold. Shaft 37 feet, following peridotite, containing copper carbonates as films on joint faces.

At 37 feet, at end of drive dipping north-west, gossan is making with seams of copper sulphide; here there is probability of about 1 foot of fair sulphide ore.

Strike N. 40° W.; dip slight, north-easterly.

Close by in Spring Creek and Spring Gully, near old cinnabar leases, stains of copper carbonate are lightly distributed. Dunbar, Bailey, and party are in receipt of aid for sinking in slightly impregnated serpentine of very unpromising character.

Further down Spring Gully, in Twyford's claim, copper ore associated with chromite and calcite occurs, but is of no importance.

Tingha Division.

Hoy's Reef, Sandy Creek.—Inspector J. Carthew, reports that this reef consists of quartz with galena, zinc-blende, and copper pyrites, and has a thickness of 2 feet. Several other veins occur S.E. of it, one apparently larger. Strike N. 70° E., dip S. 20° E.

Barraba Division.

Ironbarks Lode, Wood's Reef, parish Tiabundie, county Darling.—First opened by C. Orchard, 1887; a small parcel of ore sent away.

Held by present owners—E. Jeffray and party—since February, 1907. Country hard, red jasperoid quartzite. Lode occurs in bank of Ironbark Creek and strikes N. 20° W.

Proved by four openings and a short tunnel for a length of 260 feet, and a depth of 26 feet. The oxidised ore consists of gossan, with carbonates in cliff face. In the lowest levels, sulphides of very low copper grade are making 6 inches to 8 inches wide.

From the evidence of the creek-bed openings the lode, or patchy impregnation, makes into low grade iron sulphide of discouraging composition. A little good-grade ore was obtained from a bunch in the 26-feet shaft.

An assay of material from the west end of the tunnel, made at Gulf Creek, yielded:—

Copper	0·8 per cent.
Gold	3·2 dwt. per ton.
Silver	4·2 „ „

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PEEL AND URALLA MINING DISTRICT—*continued.*

Tingha Division.

Lady Mary Mine, 3 miles from Copeton, towards Inverell, parish Copeton, county Hardinge, on north side of Cope's Creek.—Inspector J. Carthew reported (P.B. $\frac{4}{0}\frac{8}{0}\frac{2}{}$) quartz showing copper ore in decomposed slate.

Aided to sink to 100 feet. At 61½ feet country hard; vein, 1 ft. 6 in. to 2 feet wide. At 75 feet prospects not improving. Abandoned.

Bingara Division.

Mandourie Paddock, 20 miles from Ashford, parish Warialda, county Arrawatta.—Inspector J. James reported (P.B. $\frac{2}{0}\frac{2}{7}\frac{4}{}$) a lode 1 foot wide carrying black copper ore and silver; said to assay up to 27 per cent. of copper and 20 oz. of silver per ton. Exposed for a length of 12 feet in an open trench.

Aided to sink 25 feet.

Mona Copper Lode, M.L. 6, parish Gouron, county Murchison, Top Bingara.—Discovered by D. McCarthy and W. Madden, May, 1907.

Two lodes about 30 feet apart. Strikes N. 55° W., dip slight to the north-east.

East lode opened by shaft to 45 feet. Ore struck at 25 feet. Gossan at surface. Channel 1 to 3 feet wide. Ore in lenses from an inch or two to 12 inches thick, of good quality. Country chloritic slate, with bands of red jasperoid quartzite with strings of quartz.

West lode opened by shaft to 29 feet. Ore struck at 18 feet, low grade and refractory; consisting of copper pyrites leanly distributed in hard quartzite. Channel 2 to 3 feet wide.

Mount Everest Copper Mine, M.L. 2, parishes Gouron, Dinoga, and Macintyre, county Murchison, about 1½ miles from Top Bingara Post Office.—Strike N. 75° W. Discovered by W. Power about 1894. In 1900, aid was granted to prospect. Power, Smith, and Carey sank 150 feet, then sold to W. H. Trewenack, who drove a crosscut tunnel 270 feet to cut the lode at 130 feet. Lease afterwards secured by W. Smith, of Newcastle, who let on tribute to Hoskins, Akerman, and Daly, for about two years. The tributers despatched between 600 and 700 tons of ore to Waratah, for a reported average of 14 per cent. copper.

A winze was sunk 14 feet below the tunnel (130-feet) level—not open to inspection. Partly enriched sulphides at 130 feet. Bunches of rich grey sulphide extracted from oxidised zone. Kindly gossan in outcrop. Country chloritic slate and red jasperoid quartzite with quartz veinlets.

Length of ore lens, 100 feet, by a width of 16 feet, at 130 feet level. Blanks at both ends beyond ore body. Very desirable that the lower sulphide zone should be tested below sphere of enrichment.

In 1907, Messrs. Greenway and others erected a small blast furnace of about 40 tons daily capacity to treat the ore in sight about the 130-feet level. First trial of smelter began 18th December, ran intermittently until 8th January, 1908. During this campaign 500 tons were mined from the tunnel stopes, of which about 200 tons were smelted for about 45 tons of matte.

Mount Lauff Copper Lode, in W. Morris' C.P. Lease, parish Goorin, county Murchison, about 3 miles easterly from 7-mile peg on Bingara-Barraba road.—Opened by shaft to 90 feet; crosscut west 14 feet at 50-feet level; driven north 20 feet at 60-feet level.

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The section of outcrop at shaft exposes 16 to 17 feet of alternating crushed clay stones and ferruginous quartzites with copper stains in places. At bottom of shaft a few small kernels of rich sulphide occurred (a few pounds only). Aid received for sinking 50 feet deeper.

Nundle Division.

Mount Pleasant Copper Mine, Dungowan, about 28 miles from Tamworth, county Parry.—Mr. C. S. Wilkinson in 1885 reported that "at Mount Pleasant, on Dungowan Creek, Mr. T. Hole has had a shaft 50 feet deep sunk in prospecting for a copper lode, where the altered red jasperoid slates are traversed by a small irregular vein a few inches thick of gossan, quartz, and serpentinous clay containing carbonates of copper. It is evidently a decomposed vein of copper and iron pyrites, and of no value as a copper lode; but in one specimen I detected free gold, and I would advise further prospecting to ascertain if gold does not exist in payable quantity. Jasperoid rocks appear at the surface for about 10 chains in a north-easterly and south-westerly direction, and in places are stained with carbonates of copper."

Three mines are known in this locality—the Dungowan, the Kurrajong, and the Mount Pleasant.

In 1886, several tons of ore from the Mount Pleasant Mine were tested and found auriferous but not payable.

Mr. Warden Jones, writing under date 19th July, 1898, stated that the mine occurs on a conditional lease, and that a permit was granted to G. Hyde in 1897, but no work was done under this authority.

Inverell Division.

Mundowie Copper Lode, Fraser's Creek, parish Mandoe, county Arrawatta.—Discovered by E. Devlin. Copper, silver, and lead ores reported. Striking N. and S. in slate; dip east. Opened to 20 feet; width, 2 feet.

Barraba Division.

Murchison Lode, 1½ miles north of Gulf Creek Mine, M.L. 5, parish Capel, county Murchison.—Lode 1 to 4 feet wide, bunchy, opened to 50 feet.

Fifteen hundredweight of ore purchased by Gulf Creek Company at 11 per cent. copper; 1¾ tons, at 3·35 per cent.; 10 tons of 3 per cent. at grass.

Tamworth Division.

Namoi Copper Mine, M.L. 4, parish Attunga, county Inglis, about 9 miles from Attunga Railway Station.—Discovered by J. J. Wade in 1903.

Inspector D. Milne reported (P.B. $\frac{40}{0}\frac{22}{4}$) lode well defined, about 10 inches wide, carrying veins of copper ore.

Aided to continue tunnel from 33 feet to 100 feet.

Progress.—At 100 feet in tunnel, hard rock; at 130 feet, no prospects. Two ore bodies reported. Aid allowed for 50 feet driving along shoot passed in tunnel.

Aided to sink winze 50 feet on formation 3 ft. 6 in. wide at 9 feet from tunnel entrance. (P.B. $\frac{40}{0}\frac{17}{4}$.)

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PEEL AND URALLA MINING DISTRICT—*continued.*

Inspector J. James reported (P.B. $\frac{1}{0}\frac{6}{6}\frac{2}{}$) a short shoot of sulphides of fair quality at 56 feet in winze, 2 to 4 inches thick, apparently passing into footwall.

Aided to continue winze to 100 feet. Ore vein passed through at 83 feet. Sinking discontinued. Driven S.W. for 50 feet at 83-feet level, passing through ore shoot at 25 feet from shaft; remainder of drive in country. Vein reported to average from 1 ft. 6 in. to 2 feet in drive, but low grade.

The following samples were selected by the Writer from bagged and stacked ore at the mine:—

Assay No.	Description.	Copper, per cent.	Silica, per cent.	Gold, per ton.			Silver, per ton.		
				oz.	dwt.	grs.	oz.	dwt.	grs.
08-1187 ...	Dressed ore in bags from tunnel and winze.	10·80	48·70	0	2	4	0	15	6
08-1188 ...	Fine screenings from tunnel and winze.	9·55	53·10	0	1	2	0	14	3
08-1189 ...	Coarse screenings from tunnel and winze.	6·45	65·94	0	1	2	0	9	19

Bingara Division.

Prince of Wales Copper Mine, Bobby Whitlow Creek, Bingara District.—In 1878, Geological Surveyor L. H. G. Young reported that the results of exploration in the outcrop, though encouraging, were not sufficient to warrant an opinion of the extent or value of the lode. The lower levels were then under water. In 1878, 8 tons 6 cwt. and 1 ton 17 cwt. of ore from this lode were treated at the English and Australian Company's Works, Waratah, for yields of 18¾ and 6¾ per cent. of copper respectively.

Later reports state that the mine was idle after No. 1 shaft had been sunk 100 feet and No. 2, 24 feet. Two hundred tons of ore were reported to have been raised. In 1883, the mine was again taken up, but apparently nothing has been done since that date.

Spring Creek, 3½ miles S.E. of Bingara.—Inspector J. James reported (P.B. $\frac{8}{0}\frac{4}{7}\frac{2}{}$) a copper-stained formation in diorite and slate, 3 to 4 feet wide, carrying copper stains throughout. Aided to continue sinking to 50 feet.

Tingha Division.

Royal George Mine, 1½ mile E.N.E. of Tingha.—Small veins, 1½ inch thick, striking N.E., in granite, opened to a depth of 19 feet, and for a distance of about half a mile along the strike. Originally opened for tin ore to 8 or 10 feet. Copper ore (bornite) appeared at lower levels, associated with tinstone and mispickel.

Barraba Division.

Spring Creek Copper Mine, M.L. 1, parish Wood's Reef, county Darling, about 4 miles east of Wood's Reef, and 1 mile south of Barraba-Dundarra road.—Discovered by W. Browning. Inspector Carthew reported (P.B. $\frac{1}{0}\frac{8}{0}\frac{2}{0}\frac{1}{}$):

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PEEL AND URALLA MINING DISTRICT—*continued.*

"Shafts 15 feet and 25 feet; 16 per cent. copper obtained from some of the ore." Aided to 125 feet. At 40 feet very hard rock carrying small copper lode of good grade.

In 1901 Trewenack and party raised 40 tons of ore, realising £250 (*ibid.* 55–1901).

No further record until 1906, when two small parcels of ore reported to have been despatched with satisfactory results. (Ann. Rept. 56–1900).

In 1905 Inspector G. Smith reported ($^{1}\frac{8}{0}\frac{4}{2}$) two shallow shafts, about 36 feet, in strong copper and iron formation, in places 8 feet wide. Proved for about 60 feet in length. Formation uncertain and irregular. Aided to sink main shaft to 86 feet. At 49 feet sulphide ore, 15 inches wide, in slate formation, reported. No further record.

Output stated to have been about 118 tons, believed to have averaged 16 to 25 per cent. copper.

Inspected by Writer, September, 1907. Country red quartzite, jasper, and slate. Five shafts on line in a distance of about 63 feet, all shallow. Kindly gossan and carbonate ores of good grade. Ore channel lies very flat in its westerly dip. Apparent strike of outcrop, N. 10° W.; dip 56° S. 80 W.

In southernmost shaft (30 feet) gossan with carbonate of copper—low grade; 120 feet west, shaft started in hard quartzite and slate—to cut lode—down 40 feet at time of inspection; 13 tons 10 cwt. sold at Gulf Creek Mine recently, yielded an assay value of 16·5 per cent. copper.

(NEW ENGLAND MINING DISTRICT.—*Hillgrove Division.**)

Sunnyside Copper and Silver Mine, Hall's Peak, Chandler River, parish Tiara, county Sandon, about 22 miles by road from Hillgrove.—An aided prospecting party discovered loose specimens of argentiferous copper ore at this site, but failed to locate their source. Later, Messrs. Keys Bros., of Hillgrove, after a systematic search, were successful in doing so. In 1896, shortly after discovery, Chief Inspector J. B. Jaquet visited the mine, and sampled about 3 tons of ore which had been collected, the outcrop being at the time covered with loose shingle and débris, owing to the steepness of the slope on which it occurs. The assay results ranged from 39·38 to 47·51 per cent. of copper, and 10 to 13 oz. 13 dwt. 6 grs. of silver per ton. In March, 1898, the Writer visited the scene of operations in connection with an application for prospecting aid, which was subsequently granted. The copper lodes occur as contact deposits at the junction of massive intrusive quartz-felsite with slate and quartzite. Since Mr. Jaquet's inspection, two additional outcrops had been discovered on the river bank about 150 yards north of the first discovery. These average from 6 inches to 2 feet in thickness so far as exposed. Strike N. 80° W.; dip N. 10° E. at 65°. The two latter occur about 15 feet apart.

The ore in the first lode consists of rich yellow sulphides, superficially coated with carbonates. In the second and third lodes the quality is depreciated by the presence of zinc in considerable proportion. At the surface the ore consists of blue and green carbonates, red oxide, and native copper; a few feet below at the river level, yellow sulphides appear, mixed with zinc and lead sulphides. Under aid the shaft was deepened to 50 feet, and a drive into the ridge extended from that level, the prospects being reported good.

* Should appear on page 311.

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PEEL AND URALLA MINING DISTRICT—*continued*.

The following assays were made of samples selected by the Writer:—

No. 2 lode—(Carbonate and oxide, chalcopyrites, &c.).

$\frac{1}{0}\frac{1}{8}$	Metallic copper	22·59 per cent.
	„ zinc	4·57 „
	„ lead	7·48 „
	„ silver	5 oz. 1 dwt. 6 grs. per ton.
	„ gold	nil.

No. 3 lode—(Mixed sulphide ore).

$\frac{1}{0}\frac{5}{8}$	Metallic copper	14·32 per cent.
	„ zinc	16·04 „
	„ lead	10·07 „
	„ silver	2 oz. 3 dwt. 13 grs. per ton.
	„ gold	nil.

No. 3 lode was been opened by tunnel for 70 feet under aid; prospects reported good.

The Sunnyside lodes are situated in the southern bank of the Chandler River, which runs in a precipitous valley—over 2,000 feet in depth. If payable ore is proved to occur in workable quantity, a cable tramway, after the style of those in use at Hillgrove, would be necessary for transport in and out of the valley.

PEEL AND URALLA MINING DISTRICT.

Bingara Division.

Sweet Nell Copper Lode, ¾ mile east of Mount Everest Mine, M.L. 6, parish Gouron, county Murchison.—J. Miller's shaft 50 feet, driven 10 feet; 4 tons yielded 6 per cent. In jasperoid quartzite.

Three miles south of Top Bingara, same prospector sank 40 feet, and drove 30 feet on carbonate stains at junction of serpentine.

Tamworth Division.

Trough Gully North Mine, portion P.M.L. 1, parish Piallamore, county Parry; about 17 miles east of Tamworth.—Inspector J. Carthew reported (P.B. $\frac{1}{0}\frac{2}{3}\frac{2}{2}$) a copper lode striking N. 10° E., dip nearly vertical. Aided to sink a winze 50 feet below tunnel level. Also to continue tunnel 50 feet, and 25 feet of crosscutting. Reported fruitless.

From Trough Gully it is recorded that Bregenzer and party forwarded 350 tons of ore for treatment in 1901, which yielded 7½ per cent. of copper. (Ann. Rept., 1901, p. 55.)

In 1906 about 30 tons forwarded for treatment, with reported satisfactory results (*ibid.*, 1906, p. 48). In 1907 W. J. J. Wade raised about 200 tons of ore from his mine at Trough Gully, valued at £300 (*ibid.*, 1907, p. 55).

Inspector J. James reported that the Trough Gully Mine, about 12 miles in an easterly direction from Nemingha Railway Station, Tamworth District, was taken over by a company in 1907. (Ann. Rept., 1907, p. 92.)

Greatest width, 12 feet; greatest depth of proving in August, 1908, 123 feet; greatest length of ore proved, 120 feet. Reverberatory furnace erected. Smelting started end of July, 1908, 161 tons treated.

Bingara Division.

Upper Bingara 3 miles N.E. from Upper Bingara, and ¾ mile from Mount Everest Mine, parish Gouron, county Murchison.—Copper lode in slate; strike, N.W. Aided to sink from 44 to 94 feet (P.B. $\frac{A}{0}\frac{0}{1}\frac{1}{2}^{8}$). No development.

Inspector J. James reported good patches of ore taken from this lode. Aided to drive 50 feet from 50-feet level (P.B. $\frac{1}{0}\frac{1}{0}\frac{1}{0}$).

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PEEL AND URALLA MINING DISTRICT—*continued.*

Miller and party took up land previously held by R. Bennett, M.L. 4, parish Dinoga, county Murchison; on same strike of country as Mount Everest lode. Outcrop discovered in 1887—copper sulphide in quartzite. Strike N.W. Two lodes about 50 feet apart. Copper ores, 6 to 15 inches wide, occurring in bunches. Maximum depth of proving, 90 feet; crosscut, 50 feet to 60 feet; shaft on second lode. Driven on 25 feet at 65-feet level.

Gross output 13 tons, averaging about 19 per cent. at Waratah.

Victory Lode, M.L. 4, parish Dinoga, county Murchison; adjoining Mona lode on N.W.—Originally prospected for gold in a wide bed of ferruginous jasperoid quartzite. R. Bennett struck copper about 1903. Two lodes occur, striking N. 40° W., and dipping N. 50° E. at 75° (about). Shaft 86 feet deep on east line. Crosscut to west line at 60-feet level. A small vein of good sulphide, about 1 ft. 6 in. wide at greatest, cut in west reef. East lode apparently not productive. Nineteen tons of ore despatched, mostly from West lode, yielded from 11·6 to 21 per cent. of copper at Waratah.

Walcha Division.

Walcha District.—Copper ores are reported at the following localities in this division:—

Walcha Creek, near Nowendoc.

Blue Mountain Creek, 19 miles north-east of Walcha.

Jones's Reef.—From here a sample ($\frac{A}{6}\frac{B}{7}\frac{a}{8}$) yielded—copper 10·97 per cent., and silver 13 oz. per ton.

In May, 1873, the English and Australian Smelting Company, Waratah, received two consignments of ore from this district, probably from one of these localities, which yielded as follows:—

9 tons 11 cwt., 21$\frac{3}{4}$ per cent. of copper.
,, 5 ,, 22$\frac{1}{4}$,, ,,

Bingara Division.

Warialda.—Traces of copper occur on G. Hamilton's Improvement Lease, parish Adams, county Burnett, near Warialda-Bingara road. Limestone and chromic iron also occur in this lease in the serpentine belt. The former is burned for local requirements. A little chrome has been mined for the Conrad Mines at Howell, for use in the new furnace bottom. Evidently occurs in small bunches only.

Limestone alongside railway line about 1 mile east of Warialda railway station, is also mined for flux at the same mines, and burned for local purposes. It occurs in altered Carboniferous or Devonian claystones and red jasperoid quartzites, striking about N. and S., with isolated patches of Mesozoic conglomerates and sandstones capping highest points of ridges. Width of limestone, about 2 chains at greatest.

The quality of the limestone is shown in the following partial analysis:—

	No. 07-6407—1 mile east of Warialda.	No. 07-6408—Hamilton's
Calcium carbonate ($CaCO_3$)	98·28	98·07
Magnesium carbonate ($MgCO_3$) and undetermined	·08	·43
Ferric oxide and alumina $Fe_2O_3 + Al_2O_3$	·22	·28
Gangue	1·42	1·22
	100·00	100·00

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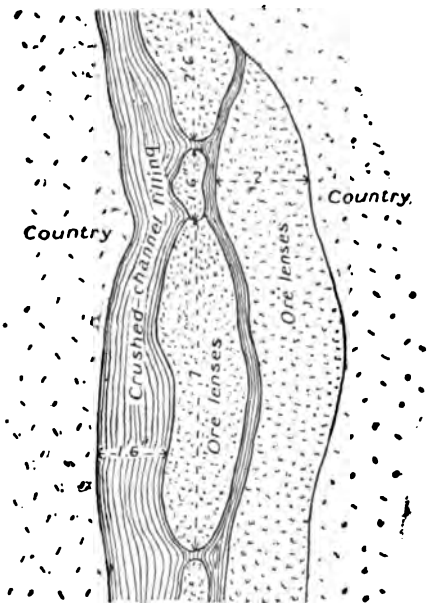
PEEL AND URALLA MINING DISTRICT—*continued.*

Barraba Division.

Wilpina Copper Lode, M.L. 6, parish Wood's Reef, county Darling.—Discovered by V. Salter about 1899. Two lodes; strike of east lode, N. 18° W.; west lode—18 feet distant—N.W. Dips S. 72° and 45° W. Shaft sunk on east lode to 36 feet; lode dipped to west out of shaft; crosscut west from 36 feet level, cut west lode in 18 feet. Followed latter down 35 feet from intersection at time of inspection (September, 1907).

East lode worked for carbonates down to about 30 feet; pinched to about 4 inches at 33 feet of shaft, about 7 inches showing in crosscut west. Opened along its length for about 140 feet by four shafts, ranging in depth from 12 to 36 feet. Driven northerly from latter for 33 feet to next shaft.

The west lode shows about 7 inches wide in roof of winze at south-east end; stronger to north-west. At 23 feet in winze, ore channel 4 ft. 6 in. wide, between well-defined walls; 3 ft. 6 in. of solid sulphides showing for a few feet. The mode of occurrence in lenses is illustrated in the following section, at north end of winze, at 23 feet.



An average sample of the ore raised from this lode yielded:—

No. 07-6447—	Copper	7·45 per cent.
	Iron	31·22 „
	Sulphur	27·02 „
	Silica	12·52 „
	Gold	a trace per ton.
	Silver	8 dwt. 18 grs. per ton.

Wood's Reef, 2 miles south of the village of Wood's Reef. Parish Wood's Reef, county Darling.—Inspector J. R. Godfrey (P.B. $\frac{22}{5}\frac{2}{6}\frac{1}{1}$) reported that the lode strikes N. 30° W., and dips south-westerly in quartzite. Its thickness is about 6 feet. The ironstone and gossany cap is more or less stained with copper carbonates, and rich carbonate ore occurs at the south end.

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A parcel of 2 tons 13 cwt. of ore from this lode, treated at the English and Australian Smelting Works, Waratah, yielded 14⅛ per cent. of copper.

Aided to sink 50 feet.

Progress,—At 22 feet, some fair copper ore, lode about 7 feet wide. No further sinking at this site. Aided to sink another shaft, from 22 to 72 feet. At 44 feet, lode reported to be opening well, ore good. Tunnel being driven to intersect. Aid allowed for 200 feet of tunnelling from site, about 300 feet south of shafts, to cut lode at 200 feet. No further record.

Inspector J. Carthew reported (P.B. $\frac{a\,a\,a\,2}{3\,2\,2}$) a copper lode, 4 feet wide, 4 miles N. E. of Wood's Reef Post Office. Ore sent to market yielded 22 per cent.

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SOUTHERN MINING DISTRICT.

Burrowa Division.

Bachelor's Reef, portion 229, parish Olney, county King. Aided from Prospecting Vote (P.B. $\frac{1}{0}\frac{0}{0}\frac{5}{0}\frac{7}{1}$) on report of Inspector Polkinghorne, to depth of 100 feet. Lode described as copper-stained porphyry.

Progress.—At 57 feet, lode 2 ft. 6 in. wide, showing fairly well in copper. Assay sample from 90 feet reported to have yielded 3·15 per cent. copper, 1 oz. 14 dwt. silver, and a trace of gold.

Further aided to 170 feet, and cross cutting 20 feet at 118 feet. Lode in crosscut reported 3 feet wide, and showing good ore to south-east, but patchy. Shaft sunk to 157 feet, country hard. Balance of aid not utilised.

Braidwood Division.

Boro Copper Mine, about half a mile south of the Mulloon Copper Mine.—Discovered by George Scott, about 1878, in which year it was sunk 80 feet and driven 50 feet south. The country consists of slates and sandstone, with limestone in close proximity. The lode strikes N. and S., and dips west, and has a thickness of 2 to 6 feet, but is much broken and mixed with country.

Thomas and party entered into possession about October, 1898, and stoped up from the 50-feet level for a length of 50 feet, bunches of good carbonates being obtained.

The following returns were obtained from the Smelting Company of Australia, Dapto:—

7 tons copper carbonates	Copper, 18·7 per cent. Gold, 6 dwt. 6 grs. per ton.
4 „ „	Copper, 22·6 per cent. Gold, 1 oz. 1 dwt. 19 grs. per ton. Silver, 2 oz. 16 dwt. 19 grs. per ton. Silica, 31·1 per cent.
2 „	Copper, 12·5 per cent. Silica, 38·3 per cent. Gold, 1 oz. 12 dwt. 9 grs. per ton. Silver, 2 oz. 9 grs. per ton.
9 „	Copper, 15·9 per cent. Gold, 8 dwt. 11 grs. per ton. Silver, 2 oz. 2 dwt. 11 grs. per ton.
6 „	Copper, 19·7 per cent.

Sulphides of copper and iron with a little zinc sulphide appeared at the 80-feet level. A cwt. sample sent to Dapto yielded 9 per cent. of copper and 7 dwt. of gold per ton.

Copper ores have been reported and tested from the following localities in this Division:—

Thames Gully, ($\frac{2}{0}\frac{1}{0}\frac{5}{0}\frac{2}{1}$); yield, 6·5 per cent. copper.

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SOUTHERN MINING DISTRICT—*continued.*

Endrick River, ($\frac{2\,4\,4\,4}{9\,6}$); yield, 13·6 per cent. copper.

Green Creek; in 1885 a sample yielded 42·45 per cent. of copper and 29 oz. of silver per ton.

Mulloon Creek; ore yielding 22·45 per cent. copper.

Currowan Creek, about 12 miles E. of Braidwood, Inspector E. C. Whittell, stated that McGuinness's lode occurs in a belt of andesite traversing Carboniferous rocks at the head of the above creek. Large bunches of epidote and small irregular veins and bunches of quartz occur in the andesite. The quartz veins vary from a few inches to a foot in thickness, but are not continuous for more than a few feet in length or depth. Native copper and yellow and grey sulphides are present in the quartz. In 1898 two mineral prospecting areas were applied for for copper-mining at Sugar-loaf, on the Braidwood Mountains, but little work was done.

Braidwood District, 17 miles S.W. from Braidwood, on west slope of Major Mountain, east bank of Little Bombay Creek, parish Palerang, county Murray. —Inspector Milne reported (P.B. $\frac{3\,0\,2\,2}{0\,7}$) a gossan lode in granite. Strike N.W., dip S.W.; well defined and apparently 20 feet wide, carrying yellow ore in blotches; centre of lode of softer material, carrying galena.

Aided to sink 60 feet in the lode, and to crosscut 20 feet at that level.

Braidwood District, 10 miles from Braidwood on Nelligen Road, and about 3 miles east of latter.—H. I. Jensen, D.Sc., reports native copper with cuprite, glance, and gold, in basalt; native copper and carbonate visible in hand specimens; also epidote and limestone inclusions. Prospected superficially some years ago to depths of 10 to 15 feet.

Picton Division.

Bullio.—In 1906, attention was directed to this locality in the Wollondilly Valley, owing to a number of applications for authorities to enter private land for copper mining.

The following assays reveal the character of the occurrence:—

07-3404—Slightly pyritous copper-stained limestone—from authority 17; yielded:—

Copper	under 25 per cent.
Gold	a trace.
Silver	do

07-3405—From authority 17; yielded:—

Copper	4·90 per cent.
Gold	a trace.
Silver	6 dwt. 13 grs. per ton.

07-3406 Pyritous greisen, from authority 42—Copper, under 0·45 per cent.

The locality was subsequently examined by Chief Inspector Jaquet, who advised abandonment.

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SOUTHERN MINING DISTRICT—*continued.*

Nowra Division.

Bundundah.—In 1883, the Warden reported that Captain Reynolds had started a copper mine in a gully of Bundundah Creek. Shaft sunk 90 feet; driven north 40 feet, and south 30 feet, at 50-foot level. Eight to 10 tons of ore raised, estimated to yield 25 per cent. copper. Strike of lode, north and south.

In the same year Mr. E. F. Pittman reported on copper at Bundundah Creek—probably the above—and stated that a lode from 18 inches to 2 feet thick, consisting of hematite, galena, and a little metallic copper occurred here in granite. An assay gave a return of 20·8 per cent. lead, 3 per cent. copper, and 60 oz. of silver per ton.

Goulburn Division.

Bungonia District.—The Jacqua Copper Company, on Jacqua Creek, about 12 miles from Bungonia (parish Inverary, county Argyle), drove 60 feet into side of range, and then abandoned the site. From Jacqua Reef ore assaying ($\frac{2}{5}\frac{1}{5}\frac{9}{5}$) 8·18 per cent. copper, and ($\frac{2}{5}\frac{1}{7}\frac{1}{7}$) 12·4 per cent. copper was obtained.

Doctor's Copper Lode, Jacqua Creek (probably identical with Jacqua Copper Mine) was examined by Inspector E. C. Whittell, who regarded it as very unpromising: the copper ores occurring only in small veins, some mere threads, in a formation from 3 feet to 4 feet thick.

Copper ores also occur at Cryer's Arm and Spring Creeks; in the latter near its junction with the Shoalhaven River. The ore here consists of copper pyrites, galena, blende, and mispickel. The deposit was opened under aid from the Prospecting Vote, but did not prove extensive enough to work. Its assay value, determined in 1892, ranged from 13 to 22 per cent. of copper.

Captain's Flat Division.

Canning and Gibson's Mine.—This property, M.L. 86, situated 1 mile from Captain's Flat, was examined in 1890 by Mr. Harrie Wood, late Under Secretary for Mines. At that time three shafts had been sunk, 25, 50, and 60 feet respectively. (*a*) 25-feet shaft sunk through broken veins, no defined lode. (*b*) 60-feet shaft sunk on a well-defined lode, with black shaly ore, about 4 feet wide; the eastern side of the black lode-stuff contained native copper. (*c*) 50-feet shaft sunk in an irregular deposit of grey ore at surface. At 50 feet the lode was reached by crosscut, ore veins up to 1 foot thick occurring in it.

The following parcels of ore from the mine were treated by direction of the Prospecting Board:—

No. 1.—15 cwt. 2 qrs. 14 lb., consisting of carbonates of lead and copper in clayslate, with a little quartz, yielded—

Copper	6·65 per cent.
Lead	6·95 „
Gold	2 dwt. per ton.
Silver	5 oz. 7 dwt. 2 grs. per ton.

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SOUTHERN MINING DISTRICT—*continued*.

No. 2.—2 tons 19 cwt. 3 qrs. 18 lb. carbonate of lead, with a little carbonate of copper, in ferruginous clayslate, yielded—

Copper	1·42 per cent.
Lead	9·97 „
Silver	3 oz. 6 dwt. 23 grs. per ton.
Gold	Nil.

No. 3.—17 cwt. 3 qrs. 18 lb. carbonates of copper and lead, with a little chalcopyrite, in clayslate, yielded—

Copper	13·40 per cent.
Lead	4·85 „
Silver	4 oz. 3 dwt. 7 grs. per ton.
Gold	Nil.

No. 4.—1 ton 0 cwt. 1 qr. 8 lb. carbonates of copper and lead, with a little chalcopyrite, in clayslate, yielded—

Copper	12·45 per cent.
Lead	10·45 „
Silver	4 oz. 16 dwt. 10 grs. per ton.
Gold	Nil.

Goulburn Division.

Chisholm's Freehold, Merrilla, adjoining Gillett's Lucky Hit Mine, parish Gurrunda, county Argyle.—A cross lode, strike N.E., dip N.W., crossing Lucky Hit lode on S.W. strike; slate country; contorted. Two shafts 45 feet apart, and open cut where Lucky Hit line crosses. Deepest shaft 65 feet, showing lean sulphide ore at bottom; bouldery and silicious. Ores occur as impregnations in slate—irregular owing to contortion. Nothing payable yet disclosed.

Ulladulla Division.

Conjola Creek, parish Little Forest, county St. Vincent.—Copper ores occurs in highly-altered rocks in the bank of Conjola Creek, near its head. The outcrop of original discovery was but a few feet in length, and dipped under the bed of the Creek, which is a permanent stream. The ore consisted of refractory iron and arsenical pyrites, with chalcopyrite. At the outcrop a little carbonate stainings occured, but were merely superficial. Assays of selected samples returned very little copper, and but traces of gold and silver.

Inspector D. Milne (Ann. Rept., 1907, p. 81) stated that the copper lode being prospected at Conjola Creek, follows "the trend of the latter, and is, therefore, difficult to test. Some very good bunches of ore are showing along the creek bed, and it is intended to cut the lode with a vertical shaft at a depth of 100 feet.

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On a parallel lode, about ½ mile north-west, Shoebridge and party are prospecting a lode from 4 feet to 10 feet wide, consisting of yellow ore impregnated through the country rock.

Goulburn Division.

Cullerin Copper Mine, portion 12, parish Milbang, county Argyle.—Taken up by C. H. Wakefield in 1906, under authority to enter. Originally opened by S. Murray in 1895. Close to railway line about 3 miles from Breadalbane railway station.

Wakefield received aid from the Prospecting Vote to sink 75 feet and drive 50 feet in No. 2 shaft. Has sunk 103 feet on underlay, which is to the east at 1 in 6. The strike being about N. 10° W.

From the 100-feet level a crosscut was driven west towards a massive outcrop of brown and specular iron oxide, having a length of 500 feet by a maximum width of 100 feet. This iron lode continues on a N. 10° W. course to the Lal Lal, or Hannam's Iron Mine, about 18 chains distant. At the latter a considerable amount of flux was at one time quarried for the Cockle Creek Smelting Works.

The Cullerin lode consists of iron oxide and chlorite, with a little copper carbonate. At the 100-feet level the transition to pyrite and chalcopyrite is manifest.

About 50 feet of rotten quartz-felsite intervenes between the lode and the big iron mass on the west. On the footwall of the former about 8 feet of rotten chlorite occurs. The Cullerin lode originated from decomposition of an intrusive hornblendic dyke, from which iron oxide has segregated. It is highly probable that the large ironstone mass on the west has had a similar origin. Chlorite has also been developed.

At the 100-feet level in No. 2 shaft, the ironstone is passing into pyrites, and in its joints stains of copper carbonate are visible. The future of this prospecting venture depends on the cupriferous contents of the unaltered pyrites; if 2½ or 3 per cent. is present in a massive body of pyrites, it will be profitably worked. The thickness exposed at 100 feet, where the hanging wall had not been reached, was about 8 ft. 4 in. of chlorite and iron ore. An average sample chipped from the full width gave the following returns:—

No. 07-3462—	Copper	2·70 per cent.
	Silver	a trace per ton.
	Gold	2 dwt. 4 grs. per ton.

From 3 feet of copper-stained chlorite and iron on the hanging wall side 0·60 per cent. of copper only was obtained. From 1 ft. 10 in. on the footwall, where the transition to sulphides was manifest, better results were obtained:—

No. 07-3463—	Copper	5·70 per cent.
	Sulphur	11·33 „
	Silica	36·90 „
	Gold	a trace per ton.
	Silver	2 dwt. 4 grs. per ton.

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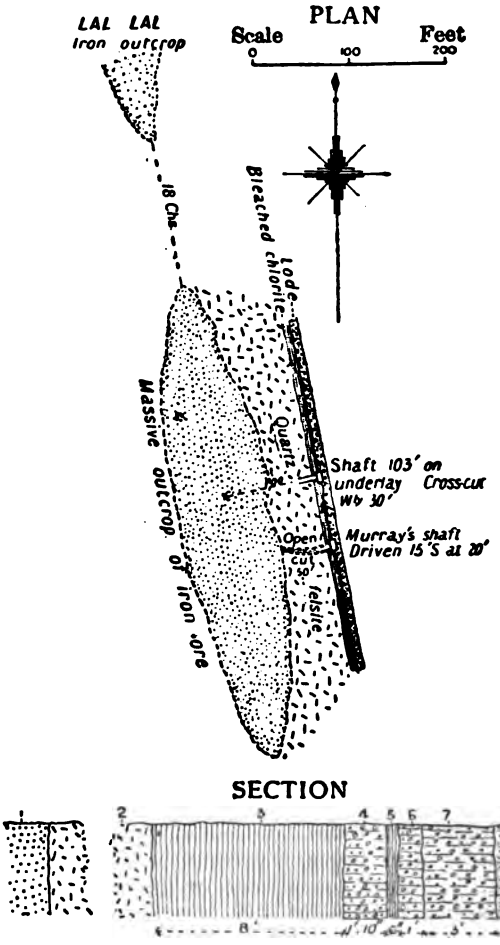
SOUTHERN MINING DISTRICT—*continued.*

The following transverse section reveals the mode of occurrence and location of assay test samples.



1. Iron ore deposit.
2. Quartz-felsite.
3. Bleached chlorite schist.
4. Iron and chlorite with carbonate of copper stains, Sample No. 07-3463.
5. Chlorite (soft).
6. Chlorite and iron.
7. Chlorite and iron with copper carbonate, Sample No. 07-3461.
8. Chlorite and iron ore.

Sample No. 07-3462.

A sample from the Lal Lal end of the iron lode, where the ironstone flux was quarried, was tested for the presence of copper:—

No. 07-3465—Copper.....under 0·1 per cent.
Gold..... a trace per ton.
Silver..... 2 dwt. 4 grs. per ton.

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SOUTHERN MINING DISTRICT—*continued.*

Curra Creek Mine, 11 miles from Tarago.—Opened in 1905; a few tons of rich ore raised.

Mr. E. B. Barber states that he has been following a pipe down to a depth of 105 feet on underlay, from which ore was raised realising about £400; the expenditure, however, exceeding the value. The underlay proving too costly, a syndicate was formed for the purpose of sinking a straight shaft in the hope of striking a main lode.

Collector Division.

Currowong Copper Mine (afterwards the *Phœnix*), about 3 miles from Lake George, 22 miles from Goulburn, and 13 from Bangalore Railway Station.—The copper lode worked in this mine was discovered by the presence of characteristic ores in the outcrop, samples from which assayed at the Sydney Mint at the rate of 27·90 per cent. of copper, 10·79 per cent. of lead, and 9 oz. 16 dwt. of silver per ton. The first shaft was sunk through gossan, various assays of which yielded from 11 to 14 dwt. of gold, and 5 oz. of silver per ton.

Mr. W. O. Cooper, on whose property the mine is situated, states that it was originally in the possession of Thos. Clark, who, about 1862, brought specimens of carbonate ore to Mr. Joseph Bull, of Goulburn, who eventually purchased the property, and in turn sold to Manton for £1,000, who formed a company to mine for copper.

Two lodes occur in slates and sandstones, associated with a highly altered igneous rock, now consisting largely of epidote—probably originally a diorite.

In 1865 a company was formed to work the deposit, under the title of the Currowong Copper-mining Company, capital £60,000, in £1 shares, having obtained the mine by purchase from the prospectors.

The first report of the company was issued on the 31st December, 1866. From it it appears that a well-defined lode was discovered soon after the company entered into possession, but it had to be followed down some depth before ore was obtained of sufficiently good quality to justify transit to Sydney.

During the last four months of the period mentioned, about 1,000 tons of 14 per cent. ore were forwarded to Sydney. This amount—less a small parcel sent to England—was delivered to the Newcastle Smelting Works for treatment, from a part of which 44 tons of refined copper were produced. A large sum was expended in machinery for the mine. The carriage of ores and machinery formed a heavy item in the expenditure, as the railway had not then reached Mittagong. A dividend of 10 per cent. was announced after writing off £7,218 for preliminary expenses, and carrying to profit and loss account £2,245.

In the third half-yearly report, ending 31st December, 1867, it is stated that the first smelting operations had not, so far, proved satisfactory, chiefly—according to the manager—on account of the "refractory nature of the ores and the inferior quality of the imported firebricks."

Local firebricks, manufactured on the property, however, answered every test.

The lode at 90 feet was reported to be 26 feet wide. At 162 feet, 15 feet of lode-matter had been exposed without revealing the hanging-wall. The length of proving along the lode was 325 feet.

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The following shafts had been sunk:—

Mitchell's shaft, depth	168 feet	.....	135 feet through lodestuff.
Wolfskehl's	„ „	77 „	.....	Average width of lode in these workings reported fully 15 feet.
Bell's	„ „	66 „	.....	
Engine	„ „	76 „	.....	

During the half-year 1,100 tons of ore were raised.

In the fourth half-yearly report six furnaces were stated to be in full work, reducing the ore to regulus, in which form it was found more profitable to despatch it than to attempt refining at the mine. Contracts were entered into with the smelters to convert 5,000 tons of ore into regulus by the end of October ensuing, and to erect additional furnaces. About 2,500 tons of ore were handed over to the smelters during the half year.

In 1869 the company was wound up, and in 1872 reformed as the Phœnix Copper-mining Company.

A progress report of the latter, dated 30th January, 1872, states that the mine had fallen into the hands of the Mortgagees of the Currowong Company, who leased it to some of the former employees working co-operatively. The operations of the latter are reported to have yielded about 450 tons of copper or its equivalent, which gave a net dividend of £18,000. Mr. Holman, reporting for the Phœnix Company, stated that during the previous eleven months a party of six miners (shareholders), in conjunction with Deer & Co., had extracted, in round numbers, about 4,000 tons of ore, from which 298 tons of copper had been smelted, 560 tons of regulus and ore sent to Newcastle, leaving about 700 tons at grass. The ores sent to Newcastle are stated to have averaged 12 per cent.

In the second half-yearly report of the Phœnix Company 82 tons 12 cwt. 1 qr. 14 lb. of fine copper are stated to have been produced, as compared with 135 tons for the previous half-year. In mining all the ore was being taken out, for it was found that during the operations of the working shareholders after suspension of the Currowong Company only the best ore was picked out—an evil only too likely to occur under such conditions in the absence of supervision; temporarily rich returns may thus be made at the expense of systematic mining—in fact, at the ruin of the mine.

No further particulars are available of the operations of the Phœnix Company, but Mr. D. H. Thomas stated that he and others worked on tribute in the "new lode," a short distance west from the first discovered deposit, when the Phœnix Company held possession, this being the last work carried on under its ownership. The ore raised during the tribute averaged about 4½ per cent. copper. In the bottom of the workings the lode was 30 feet wide and of an average value of about 3 per cent. The matrix was stated to be solid pyrites, which is an important feature in view of the possibilities of pyritic smelting.

In 1896 a company under the title of the Currowong Copper and Gold Mining Company (Limited) was formed to open up the mine. The earliest workings were unwatered and cleaned out and prospecting drives put in, but the results were not encouraging, and the enterprise was abandoned when the limited capital was expended. The "new lode" referred to by Mr. Thomas was not reopened.

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In 1880, three samples of water from the Currowong Mine were analysed by W. A. Dixon, with special reference to their poisonous action on the fish in Lake George, and were therefore only examined with regard to the metals in solution. The metals were present as sulphates, and are stated below as anhydrous salts:—

	From Currowong Creek.	From Working Shaft.	From Old Shaft.
	Grains per gallon.	Grains per gallon.	Grains per gallon.
97. Sulphate of copper ...	1·12	17·67	6·42
„ zinc	16·28	53·54	7·29
„ iron	·43	1·42	·98

In May, 1907, a new Currowong Copper Company was formed to unwater and test the mine, but on reaching the bottom of the old workings in the western lode, prospects were not considered good enough to encourage continuance, and the enterprise was abandoned in January, 1908.

The most recent shaft in the eastern lode proved to be 132 feet deep, with a crosscut extending 280 feet towards the West lode. At the end of the crosscut a thin vein of quartz and pyrites was opened for a few feet. An average sample yielded on assay:—

No. 08-368—Copper..... 5·07 per cent.
Gold..... a trace per ton.
Silver..... 10 dwt. 21 grs. per ton.

The earliest and most extensive workings in this lode were not opened.

The main shaft in the West lode proved to be 186 feet deep in country on the west side of lode. The lode worked in open cut at surface appears to have been stoped down to 180 feet, where it had a width of 12 feet, the maximum width of stoping being at the 120-feet level, where it reached 20 feet.

Strange to say, the recent company was unable to find any ore by trenching the floors of the lowest level and stoped areas; a little pyritous schist or slate, however, occurred in places. A thin skin of pyritic ore, left on the wall at 120 feet, showed the following quality on assay:—

No. 08-367—Copper..... 2·40 per cent.
Gold..... a trace per ton.
Silver..... 13 dwt. 1 gr. per ton.

Below the lowest stopes a winze at the south end was cleaned out to a depth of 68 feet without reaching its bottom. This was reported to be through a

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solid pyritic mass worth 3 per cent. of copper, but recent inspection belie this report. From some of the material extracted during cleaning out, sample of the most pyritic was selected for assay. It yielded:—

No. 08–366	Copper	0·67 per cent.
	Gold	a trace per ton.
	Silver	13 dwt. 1 gr. per ton.

It is not improbable that better results would be obtained further nort under the main stopes, for it is inconceivable that the latter should mark th abrupt termination of the lode.

Provision was made for precipitating the copper in solution whilst un watering, but, contrary to expectations, the results were infinitesimal. Abou 1 ton of cement copper was obtained as scale from old iron rails and a pum left in early workings. That these were not entirely destroyed is evidenc of the weakness of the solution. The water from the eastern shaft confine in a dam apparently contains no appreciable copper salts, for stock drink i with impunity.

Bailing in both shafts was effected simultaneously by same power, by severa chains of wire cable connecting both pumping beams.

Judging by the size of the slag dump, a large amount of ore must have bee smelted. A sample of the slag taken from broken-up material at a larg number of test openings, yielded (07–3454)—Copper, 0·1 per cent.; gold. trace; silver, 6 dwt. 13 grs. per ton. An attempt to gauge the tenor of th sulphides smelted was made by selecting samples from the east and wes shafts, and from the site of the roast stalls, the results being as follows:—

07–3451—Sulphide ore from surface heap alongside shaft in open cut, West Lode:—

Copper	2·95 per cent.
Silica	8·65 „
Iron	41·02 „
Gold	a trace per ton.
Silver	19 dwt. 14 grs. per ton.

07–3452—Sulphides at grass from East Shafts:—

Copper	0·10 per cent.
Silica	57·90 „
Iron	14·88 „
Lead	4·78 „
Gold	a trace per ton.
Silver	3 oz. 0 dwt. 23 grs. per ton.

07–3543—Sulphides from old Roast Stalls:—

Copper	1·30 per cent.
Iron	36·40 „
Lead	0·25 „
Silica	7·13 „
Gold	a trace per ton.
Silver	9 dwt. 19 grs. per ton.

The sulphides from the West Lode and roast stalls (samples 3451 and 3543) are ideal pyritic fluxes, and probably account for the absence of waste material at these workings.

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SOUTHERN MINING DISTRICT—*continued.*

Donnelly and party's Mine, M.L. 4, parish Gurrunda, county Argyle.—Shaft 25 feet, passing through soft, kindly-looking gossan into sulphide zone, where bands of more or less massive iron pyrites occur in slate and dolomitic rock. A little copper sulphide also visible. In the gossan a little carbonate and red oxide, and possibly native copper, occur.

On the east, about 50 feet distant, a large lode of barytes occurs, but ferruginous and of bad colour. Gossan occurs more or less through it, and at 38 feet, in a shaft, has been intersected. No metallic ores, however, were met.

Solid barytes also occurs a little further on, near Nosworthy and party's shaft.

The carbonate and cuprite ore from Donnelly's shaft assayed 12 to 15 per cent. of copper, the sulphides, 6·5 per cent. and 11 oz. of silver per ton. Sufficient work had not been done to expose the lode either horizontally or vertically.

The dolomite gave the following results on partial analysis:—

	07-3499	07-5302
Carbonate of lime ($CaCO_3$)	46·85	46·17
Carbonate of magnesia ($MgCO_3$)	35·41	36·29
Ferric oxide and alumina ($Fe_2O_3 + Al_2O_3$)	1·70	2·38
Gangue	16·36	15·24
	100·32	100·08

Nowra Division.

Ettrema Lodes, Ettrema Creek, M.Ls. 7 to 11, parish St. George, county St. Vincent. Discovered by J. McKane and Sons and J. R. Chaffey in September, 1907. Eight miles north-westerly from Sassafras, and 28 west of Jervis Bay. The lodes outcrop in a precipitous gorge cut by Ettrema Creek, about 1,000 feet below the Upper Marine sandstone plateau, and about 1,400 feet above sea level.

The plateau sandstones and conglomerates overlie Devonian—and probably Silurian—highly-folded quartzites, slates, and silicious limestones, in which the lodes occur, with one exception, as bedded deposits, impregnations, or replacements. The pitch of the strata brings the upper metalliferous beds to the creek level as it is followed down.

The lodes consist of a complex mixture of zinc-blende (principally) mispickel, chalcopyrite, and galena.

(For further particulars see page 413.)

Frogmore Division.

Federal Copper Mine, on J. B. Cassidy's land, about 7 miles north of Frogmore.—Strike N. 10° W. vertical. Shaft sunk 80 feet, and crosscut east 40 feet at 78-feet level, in a large ferruginous outcrop. Sulphides struck

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at 30 feet, where a little decomposition had taken place. The sulphides taken out below this took fire on exposure at surface, and burnt to a loose powdery mass, a sample of which assayed:—

No. 07-6706—Copper	.....	0·30 per cent.
Gold	.....	a trace per ton.
Silver	.....	,, ,,

Solid iron pyrites occur in shaft and east crosscut for about 30 feet.

On east side of pyritic mass, native copper and red oxide coat jointings of country (averaging about 2½ per cent.) as the result of precipitation along a soakage channel; not likely to continue to any depth.

To the west of the shaft pyrites still showing. Probably a little enriched ore on back of lode might be obtained at the 30-feet level.

Judging by the cindered ore caused by natural decomposition, the pyritic mass disclosed is of too low grade for smelting purposes.

Captain's Flat Division.

Federal Mine, Captain's Flat, about half a mile east of the Lake George Mine, and 100 yards east of cutting on Braidwood road, parish Bealibi, county Murray.—Inspector J. R. Godfrey reported (P.B. $\frac{2}{0}\frac{3}{0}\frac{2}{1}$) hard quartzose and schistose country carrying iron pyrites and a little copper pyrites; striking north and south, and dipping west at a slight angle.

Aided to continue 36-feet shaft to 86 feet. A seam of sulphides passed through at about 43 feet, underlying west. At 50 feet a 1-foot vein cut, assaying 5 per cent. copper. Also dipping west.

Aided to crosscut west at 80 feet, apparently without profitable results. No further record.

Frogmore Division.

Frogmore Copper Mine (formerly *Frogmoor*), about 17 miles north of Burrowa, in parish Bala, county King; discovered in 1870, and taken up by J. Sheedy as a mineral lease.

In 1873 the English and Australian Smelting Company, Waratah, treated 4 tons 19 cwt. of ore from Frogmore for a yield of 9¼ per cent. of copper.

In the "New South Wales Mining Statistics," 1875, p. 90, this mine first receives official notice. Seventy tons of ore are reported to have been raised at this date from a lode averaging 3 ft. 6 in. in thickness at 75 feet from surface, and striking N.W. (dip, 1 in 6 westerly). The ore was estimated at 12 per cent. copper.

In 1880 work was suspended after about 50 tons of copper were produced. In 1881 the mine was floated into the Frogmoor Copper-mining Company, having previously been worked by Messrs. Deer Bros. At the end of the half-year ending 31st December, about 50 tons of copper had been produced.

In 1882 1,050 tons of ore raised yielded 118 tons of copper, 12 of which were produced by a wet process, which was not, however, in complete working order. The company was about erecting concentrating machinery to treat a large amount of lean ore at surface. Main (No. 1) shaft, 373 feet deep; No. 4 shaft, 360 feet.

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Frogmore Copper Mine.

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In 1883 mining operations were confined to No. 4 shaft. At 288 feet in this shaft a new lode was struck, which junctioned with the main lode; the former, in one place, was reported to be 17 feet wide, the general average width being 6 feet. During the year about 1,275 tons of ore were raised and smelted at the mine for 127½ tons of copper, the results of the last half-year showing a fair profit.

The plant then consisted of winding and crushing machinery, two smelting and one refining furnaces, and chambers for manufacture of sulphuric acid. Thousands of tons of poor ores—the accumulation of years—were reported at grass, which it was proposed to treat by a wet process.

In 1884 the mine was worked, but owing to the low price of copper it was closed down in January, 1885. No official returns of the amount of copper produced is given, but in 1885 it is mentioned that 60 tons of ore were raised prior to closing, which yielded 6 tons 15 cwt. of copper.

In 1886 and 1887 the mine remained idle.

In 1888 work was resumed, forty men being employed and 100 tons of ore raised. In 1889 the Mining Registrar stated that work had been recently resumed, and would be continued if the value of copper kept up. In 1890 smelting operations were continued for about three months, the balance of the year being occupied in sinking a new shaft and draining old workings.

In 1891 about 100 tons of ore only were raised. In this year Geological Surveyor W. Anderson reported that a large amount of work had been done on this property. The lodes occurring in lenticular form in the strike of slate country near the junction of intrusive granite. "The lodes occur as isolated patches in a belt of altered schistose slates, which, near the lodes, were also impregnated with copper pyrites, so that, besides the true lodestuff, a large quantity of pyritous slate was raised and treated for the copper which it contained. There is a certain percentage of silver in the ore, which, together with the purity of the copper extracted, enhanced its value in London to nearly that of Chilian copper."

Mr. I. Stevenson, of Burrowa, informed the Writer that the last shipment of copper from the mine—in 1890—assayed in London 97·60 per cent. of copper, and 37 oz. 5 dwt. of silver, and 6 dwt. 12 grs. of gold per ton.

In 1898 the only work carried on was in an adjoining block to the east of the old mine; a shaft was down about 20 feet, from which 4 tons of ore had been sent to the Australian Smelting Works, Dapto.

In 1898 the Writer visited the mine. Inspection was restricted to the surface features, as the workings were full of water. A considerable amount of "screenings" and "seconds" on the surface revealed the nature of the sulphides (which made their appearance at about 60 feet). The surface indications appear favourable for vertical persistence of the ore lenses. Prospecting was being actively carried on in the immediate vicinity, particulars of which will be found under the head of "Frogmore." The following statistical return was prepared from the company's half-yearly reports:—

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FROGMORE COPPER MINE.—Mining Statistical Table.

Half-yearly Report ending—	Tons of Ore Raised.	Tons of Ore Smelted.	Tons of Copper Produced.	Average Yield per cent.	Deepest Shaft.	Deepest Level.	Remarks.
			tons cwt. qrs. lb.		feet.	feet.	
1st report—1 Jan., 1882	500 (?)	500 (?)	50 9 1 0	9·6	317	317	One furnace at work; ore raised from No. 1 and No. 4 shafts; underhand stope in No. 4 shaft, 50 feet long; quantity of "seconds" and "smalls" reserved for further treatment: sulphuric acid chamber being erected in connection with leaching process.
2nd ,, 31 July, 1882	550	520	55 2 3 0	10·6	354	354	Lode at bottom of No. 1 (deepest shaft) yielding about 6 tons of 10 per cent. ore per fathom, in addition to dredgy ore reserved for future treatment. No. 4 shaft yielding about 7 tons of 10 per cent. ore per fathom; about 3 tons of precipitate obtained from recently-started leaching process.
3rd ,, 30 Jan., 1883	500	500	63 14 1 9	12·74	373	373	Sinking discontinued; ore chute in No. 4, 60 feet long; principal part of ore smelted from this shaft; lode about 4 feet wide; 10 tons of copper obtained from precipitates in wet process.
4th ,, 31 July, 1883	500	450	45 5 0 0	10·05	373	373	Operations retarded by drought: Handcock jig being erected; dam completed; two furnaces at work; north end of No. 4 shaft improving; large quantity of "seconds" and "smalls" raised in addition to ore smelted; little done with wet process.
5th ,, 29 Jan., 1884	800 (?)	800	82 5 0 0	10·31	373	373	New lode discovered at 288-feet level in No. 4 shaft, 17 feet wide at its junction with the main lode; average width of new lode 6 feet, yielding 8 tons of 10 per cent. ore per fathom; two furnaces at work; jigging plant started.
6th ,, 22 July, 1884	535 (?)	535	53 9 2 0	10·00	373	373	New lode not up to expectation, small, and producing about 4 tons of 10 per cent. ore per fathom; concentrating plant idle for four months owing to want of water.
7th ,, 17 Jan., 1885	... (?)	460	48 0 0 0	10·43	373	373	Copper market low; operations unsatisfactory; concentration intermittent; one furnace only at work; treatment of carbonates by wet process abandoned; ore raised by tribute from branch vein in west wall of No. 4 shaft yielded 15 per cent. dressed.
	...	3,765	388 5 3 9	10·53% extraction.		.....	

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It will be noted that the yield of the ore smelted during the company's operations averages 10·31 per cent. of copper, and, further, that as soon as the copper market became depressed operations ceased, and have practically never been renewed. The spasmodic attempt during the copper boom of 1888–9 was as brief as the boom itself. This mine certainly offers sufficient inducement for renewed effort.

A few hundred feet west of the main lode Mr. S. L. Bensusan opened another (*Pride of Frogmore*) in Mr. J. Sheedy's property, and erected a reverberatory furnace. A good deal of work was done, but the results were not satisfactory. The two properties could, perhaps, be worked together in any new venture. Samples of the sulphides from both mines were selected from heaps at surface for assay, with the following results:—

No. 99–830—Silicious copper pyrites from Frogmore Mine:—

Copper	10·35 per cent.
Iron	13·54 „
Silica	54·60 „
Silver	1 oz. 14 dwt. 20 grs. per ton.
Gold	nil.

No. 99–831—Quartz with iron and copper pyrites from Bensusan's Lode:—

Copper	3·69 per cent.
Iron	16·32 „
Silica	58·00 „
Silver	13 dwt. 1 gr. per ton.
Gold	nil.

In 1898 McInnes and Cook were working a copper-vein on the north boundary of M.C.P. 51, parish Alton, county King, belonging to the Frogmore Proprietary. A shaft had been sunk 50 feet on the vein, which traverses crushed porphyry and schist. Three tons of ore extracted down to water-level yielded 14½ per cent. of copper, and silver 6 oz., and gold 3½ dwt. per ton.

On the south boundary of the Frogmore property the same party were working a 5-acre lease under private agreement on portion 74, parish Bala, county King. Country crushed porphyry and schist, with copper carbonates in the laminæ for a distance of 17 feet in a crosscut; in fact, copper carbonate colourings are discernible through a wide belt of these rocks at Frogmore. From a more concentrated deposit in a new shaft, about 6 tons of good ore were treated at the Dapto Smelting Works for a yield of 17·6 per cent. of copper, and 5 dwt. 14 grs. of gold per ton.

On the 10th June, 1907, Mr. Francis Drake started to unwater the mine, under a purchase option. The latest, or New Shaft, sunk in 1890, being selected for the purpose, being about 100 feet lower down the hill than the Top shaft. The water stood within 30 feet of the surface; lowering it had no influence on the water in the higher level shafts south of New Shaft, the only one affected being May's, about 40 feet north; thus proving the "May" ore-lens unconnected with the southern, either naturally, by the same lode channel, or artificially by mining.

The depth of the New Shaft proved to be 360 feet, and May's 290 feet. Above the 290-feet level stoping has been carried up between the shafts to near the surface; the stopes extending for a few feet north of May's shaft, and south of the New Shaft, for a distance varying from 45 feet, at 355 feet, to a few feet near the surface.

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In the southern face of this section from 1 ft. 6 in. to 2 feet of sulphide ore is exposed from the bottom up to the 302-feet level, having an average assay value of 10·34 per cent. of copper. A sample taken from this end (not average) for the purpose of ascertaining approximate composition, yielded:—

No. 07-6716—Copper	12·75	per cent.
Iron	17·96	„
Sulphur	15·53	„
Silica	44·15	„
Gold	a trace	per ton.
Silver	4 oz. 13 dwt. 15 grs.	per ton.

The northern face exposed an average of about 2 feet of ore, assaying, according to Mr. J. F. Carey, 5½ per cent. copper.

The average width of the "May" lens must have been considerable, judging by the width of extraction; the widest portion, however, resulted from junction of a western lens with the "May."

Judging by the surface workings, the Frogmore lode, or lodes, has been opened by six shafts for a length of about 660 feet between the Top and May shafts. The unopened shafts are reported to range from 65 to 240 feet in depth.

The general strike of the workings is N. 20° W. The dip of the ore in the New Shaft is S. 70° W. at 83° in the upper levels, and 69° at 333 feet.

The New Shaft was an illadvised expenditure, being practically in worked ground, and proving nothing more than the existing May shaft, 40 feet away.

The only drive from it was to the south, which, instead of following the strike of the channel after losing the lens, turned south-easterly for a considerable distance, and then south-westerly, following throughout a most erratic course for 197 feet. The lens pinched about 18 feet south of the shaft.

From the results of the unwatering recorded, it is evident that a further test must follow in connection with the southern shafts before any criterion of the value of the lower ore reserves can be obtained. The surface dumps bear testimony to considerable ore extraction from the upper levels; and there is, therefore, reason to infer supplies of probably comparatively low grade, yet workable, ore beneath the early stopes.

Contrary to expectation—which induced provision for recovery—the water baled from the New Shaft, below a few feet, was practically non-cupriferous. This poverty was doubtless due to the complete extraction of the lode within the sphere of oxidation; thus preventing decomposition into soluble copper salts in the old stopes above the permanent water-level. For it is in the damp airways of the stopes and shafts, that the change takes place wherever poor sulphides remain exposed on the walls, or in left pillars, before the surface waters fill the workings. Below the permanent water-level the chemical change is comparatively insignificant.

The ore at grass has been estimated by Mr. Carey, acting for Mr. Drake, at 125 tons—of an average value determined by sampling, of 3·8 per cent.

The slag dump has been similarly estimated and tested—at 12,216 tons of an average assay value of 1·13 per cent. copper.

Frogmore District.—Inspector Hooke reported (P.B. $\frac{1}{0}\frac{8}{2}\frac{1}{1}\frac{4}{4}$) a copper-bearing formation in schist rock, about 3 miles north of Kenyu Station, alongside, and north of Right Hand Creek.

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SOUTHERN MINING DISTRICT—*continued*.

Lode recently opened, of large dimensions, showing copper stains freely. Aided to sink from 12 feet to 62 feet.

Progress.—At 36 feet prospects not good, country hard. No further record.

Bell View Mine, portion 112, parish Yundoo, county Monteagle.—Discovered by T. Carmody in 1907. Shaft 30 feet, on thin erratic veins of gossan, containing copper carbonates and rich kernels of grey sulphide. No defined channel nor persistent veins. Bottom of shaft in slate. A few tons of ore at grass averaging 7 or 8 per cent.

Conjuror Mine.—Stevenson's land, Goba Creek. Discovered about 1877. Taken up by J. Williams and party in 1907. Strike N. 33° W.; dip N. 57° E. at 53°. Shaft 55 feet; channel 5 inches to 18 inches. No true vein. Small prills of grey ore near surface. Bottom of shaft in country. No lodestuff.

Mount Kenyu, on Kenyu Estate. Williams and party sank 80 feet in gossan outcrop; a little carbonate and grey ore reported at 80 feet.

Right Hand Creek, 13 miles north-westerly from Frogmore, portions 21 and 41, parish Yundoo, county Monteagle.—Vein 18–24 inches wide (not solid), with yellow sulphide. Small parcel of 11 per cent. ore sent to Waratah.

Stewart and party, Flannery's land, portion 14, parish Narralla, county Monteagle, 2 miles from Godfrey's post office.—Good-looking gossan outcrop on west of shaft; but a crosscut under it, at the 73-feet level, proved only a leanly pyritic rock with calcite, iron pyrites, and a little copper pyrites and blende.

Aid was granted (P.B. $\frac{41}{6}\frac{27}{6}$) to sink to 130 feet, and for cross-cutting 50 feet at the 85-feet level.

At 95 feet cut gossan with carbonate and black oxide, without defined walls.

An examination of the workings in 1907 revealed massive limestone in the west crosscut at 73-feet level, which does not appear at surface. An analysis revealed its composition as:—

No. 07-6710—Carbonate of calcium	73·67
*Carbonate of magnesium	3·25
†Ferric oxide and alumina	4·92
Gangue (silicate of alumina and iron, and trace of lime	18·16
	100·00

* Including water and undetermined.
† Including any phosphoric and titanic oxides present.

A little pyrites was showing in face of crosscut at 70 feet from shaft.

An eastern crosscut at 83 feet, extending for 30 feet, exposed very kindly-looking gossan with traces of carbonate of copper, but undercutting at 120 feet revealed no trace of it. The disappointing results obtained at the latter level caused the aid to cease.

Right Hand Creek, in portion 106, parish Narralla, county Monteagle.—J. P. Adams received aid to sink on vein in slate and breccia; striking N. 15° E. A little ore at grass, of poor, silicious character. At the bottom of shaft traces of copper only are visible alongside a wall striking N. 40° W., and underlying N.E.

Petty and Son were prospecting on Goba Creek between the Conjuror and Carmody's Mines, in a gossany outcrop in which no true vein had been disclosed. Odd prills of grey ore were, however, reported.

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O'Malley and Peel's shafts are distant about 6½ chains north of Adams' shaft. This was the site of the original discovery at Right Hand Creek (abandoned at time of inspection). Two shafts have been sunk about 90 feet apart. It is reported that 6 tons of dressed ore from them yielded 17 per cent. of copper.

South Frogmore, 750 feet south of Frogmore engine-shaft. Shaft 95 feet, driven south for 78 feet, and crosscut west 22 feet. Seven tons of ore extracted from south drive are reported to have yielded 13·2 per cent., and 6 tons from 66 feet to 95 feet in shaft, 12·5 per cent. Another shaft, 320 feet east of the 95-feet, sunk to 90 feet, and driven north 27 feet, yielded 5 tons of carbonate ore, returning 9 per cent. of copper.

Yundoo Lode, portions 43 and 44, parish Yundoo, county Monteagle.—Discovered by J. Carmody, July, 1906. Striking N. 15°. W., in slate. Thin gossany veins with slight traces of copper carbonates, not persistent in depth; opened for 20 feet. Traceable by gossan outcrop in places for a short distance south. Not promising for permanence or size.

Watson and party, No. 437 (Yass), parish Congera, county Monteagle.—Prospecting alongside old shafts sunk many years ago for copper. Carbonate stains in crushed porphyry.

Yass Division.

Good Hope Copper Mine, situated on the north side of the Yass River, about 17 miles from Yass, in portion 1, parish Woolgarlo, county Harden.—This was probably one of the earliest-opened copper mines in the Colony. In a despatch from Governor Sir Charles Fitzroy to the Right Honorable Earl Grey, dated 1st March, 1849, mention is made of copper mines in operation in the neighbourhood of Yass and at Molong (Copper Hill).

The ore consists of copper carbonates, sparingly distributed through a quartzitic matrix.

Mr. Argyle McCallum (whose father originally owned the land), under date 7th August, 1898, supplied the following particulars:—Several rich patches of ore have been found, but the main body of the lode is of low grade, the ore being too disseminated through the large mass of matrix. About forty-seven years ago the Scottish-Australian Mining Company expended a considerable sum prospecting the Good Hope lode, and it was reported that at a depth of 180 feet a lode of sulphide ore was cut, about three-quarters of a mile from the main outcrop, which lies about 55 chains from the Yass River, at an elevation of about 300 feet above it.

About 1896, 100 tons of silicious ore, dressed from the outcrop, were forwarded by Thomas Rowe and party, to W. H. Trewenack, for fluxing low grade copper matte of high silver value. It averaged 11 to 12 per cent. copper, and consisted of cuprite and native copper.

Examined by Writer in 1898 and 1908.

The main lode presents a strong outcrop for about 20 chains; beyond this it thins out, and apparently disappears. Numerous shafts have been sunk along its course, as well as open cuts. The former are all fallen in; hence inspection is entirely confined to the outcrop, which consists of a rugged mass of ferruginous quartzite and quartz, with traces of copper carbonates, and, in places, cuprite and native copper. Some of the shafts have cut into a very carbonaceous slate.

On the bank of the Yass River, near the north-east corner of portion 2, a bluff of fine-grained sandstone (quartzitic) and slates with thin quartz leaders, forms the bank of the river channel. Copper carbonates stain joint

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and bedding planes; and a little copper pyrites is discernible, sparingly distributed. The principal dip at the shaft level is S. 50 W. at 27°; but folding is conspicuous.

About 1 chain from the river a shallow shaft has been sunk to the copper level—a few bags of dressed ore at surface being of very low grade.

About 13½ chains N. 60° W. from the S.E. corner of portion 1 is the site of the sulphide lode referred to by Mr. McCallum.

This lode was intersected in an eastern crosscut from a vertical shaft, at a depth of 169 feet. The workings being recently unwatered, the strike of the lode was found to be N. 20 W., and the dip of the hanging wall about S. 70° W. at 65°. Thickness, 7 feet.

The average value of the ore exposed is: copper, 3·43 per cent.; iron, 7·03 per cent.; silica, 73·75 per cent.; sulphur, 4·40 per cent.; silver, 1 oz. 5 dwts. 14 grs. per ton; and a trace of gold. It is uncertain whether it is a continuation of the Good Hope lode.

At Goodna Creek J. B. Jaquet reported (Ann. Rept. 1896, p. 138) that gold occurs in thin veins ⅛ to ½ inch thick, composed of quartz, limonite, and copper carbonates. For 1 or 2 inches on either side of the veins the country rock is impregnated with gold.

Goulburn Division.

Goulburn.—(*See* Currowong, Merrilla, Cullerin).

Copper ore is also reported from Baw Baw, and at Lockyersleigh, where a copper lode of low grade was opened by shaft prior to 1863, but proved then unworkable.

Captain's Flat Division.

Grogan and Singleton's Copper Mine.—This property consists of a 40-acre lease adjoining the Old Commodore Vanderbilt Mine. Mr. H. Wood, late Under Secretary for Mines, who inspected the mine in 1890 in connection with the Prospecting Vote, reported the lode to have a thickness of from 4 inches to 18 inches, a meridional strike, and well-defined walls. Three tons of ore raised during sinking operations to 75 feet, and driving 20 feet from the 45-feet level, were tested at the Clyde Smelting and Chlorination Works, with the following results:—

Smelters assay—Metallic copper	29·59 per cent.
Chemical „ „	31·19 „
Silica	22·17 „
Silver	10 dwt. 21 grs. per ton.
Gold	a trace (under 2 dwt.)

Heffron's Creek, parish Gurrunda, county Argyle.—Messrs. Heffron, Nosworthy, and Le Champ, tunnelled into very graphitic slates outcropping in the bank of the creek. Small blebs and veins of quartz occur rarely, and still more rarely specks of copper sulphide and pyrites, which are confined to the quartz. Native copper occurs in thin plates, and specimens have been washed from the crushed outcrop. This occurrence is unlikely to improve.

A shaft was started higher up the bank in a ferruginous slate breccia simulating gossan. These breccias represent the cemented detritus of an earlier channel level lying uncomformably on the edges of the slates, here, and at other points of the creek course through a rugged gorge of some length.

Goulburn Division.

Jasper's Gully, 60 chains north of Manton's Reef, and 22 miles from Bungonia, parish Narramungar, county Argyle.—Inspector H. Hooke reported

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(P.B. $\frac{a}{5}\frac{g}{7}$[1]) a formation about 12 feet wide carrying copper, lead, gold, silver, &c., in a remote gorge of the Shoalhaven River. Country slate; opened in various places by J. Mackie and D. Hockey. Other veins exposed in proximity.

Jerralong.[1]

(LACHLAN MINING DISTRICT.—*Yass Division.**)

Kangiara Mine, G.Ls. 1,158 and 1,159, parish Taunton, county King, on Burrowa-Yass Road, and about half a mile from Burrowa River, 12 miles from Binalong railway station.—Discovered by J. Alder in 1899. Opened in July, 1902. Strike N. 10° W., dip (slight) easterly.

Deepest proving—to September 30th, 1907—83 feet; Greatest length, 235 feet. Ore strong at both ends. Two shafts to 60-feet level; two winzes from latter to 83 feet.

In the oxidised zone two lodes occur about 10 feet apart, with flat leaders between. The eastern lode had not then been proved from the 83-feet level in the main lode.

The width of ore exposed in the winzes in the main lode varied from 4 to 5 feet, averaging about 4 feet; mostly solid sulphides. Copper sulphide makes on footwall in higher levels, on hanging wall at lower.

The ore consists chiefly of galena, with chalcopyrite and zincblende, the latter reported not to exceed 3 per cent.

The total output to 20th September, 1907, was 1,500 tons, 1,400 of which were despatched for sale at Cockle Creek.

One thousand two hundred tons sold to 1st June, 1907, averaged about:—

Lead	30 per cent.
Silver	30 oz. per ton.
Gold	5 dwt. ,,

The composition and value of the ore in the lower levels is illustrated in the following table of the latest returns:—

Quantity.	Lead, per cent.	Copper, per cent.	Gold, per ton.			Silver, per ton.			Remarks.
Tons.			oz.	dwt.	grs.	oz.	dwt.	grs.	
37	31	11	0	4	0	25	13	0	
30	23	8	0	6	0	28	0	0	
11	5	18	0	10	12	33	9	0	Picked for copper values.
10	3	19	1	15	0	48	0	0	,, ,,
38	20	16	0	4	0	21	0	0	
20	28	14·3	0	8	0	26	0	0	

In 1907 the mine was held for some time by Messrs. Horton and Freeman under a purchase option, during which the two winzes were deepened about 20 feet each, making a depth proved about 100 feet; a little driving was done from this level. The lode persisted to the depth mentioned; but after considering a second option, the purchase was not effected.

SOUTHERN MINING DISTRICT.

Captain's Flat Division.

Lake George Copper Mines.—Situated at Captain's Flat, 25 miles south of Bungendore Railway Station. Elevation about 2,700 feet above sea-level. District well-wooded, with good rainfall.

[1] *Goulburn Division.*—Jerralong Creek, near junction of Shoalhaven River, copper vein about 1 feet wide. Unopened. Taken up in 40-acre lease by J. Mackie, parish Jerralong, county Argyle, January, 1907.

* Should appear on page 276.

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Captain's Flat, with Lake George Copper Mines and Smelting Works.

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Mr. J. E. Wright, about 1874, when engaged on Foxlow station, near Captain's Flat, first noticed copper ores in the vicinity, but mining did not start until 1882, when the discovery of a promising copper lode was announced by the Under Secretary for Mines.

In 1884, Warden Woore reported that 2,380 tons of gossan ore had been crushed for 360 oz. of gold (about 3 dwt. per ton). Another parcel of 800 tons yielded 6 dwt. per ton. He further stated that "the character of the reef is an auriferous gossan, overlying a large copper lode of low percentage."

In 1885, blast-furnace treatment superseded the battery, and the two furnaces erected were run intermittently until 1889, when three additional, and a 20-head stamper battery and Huntingdon Mill, were added to the plant.

In 1890, heap roasting of the sulphides was in operation at the Koh-i-noor Mine, whilst at the Commodore a revolving calciner was erected for the fines.

In 1894, the two mining companies—Koh-i-noor and Commodore Vanderbilt—were amalgamated under the name of the Lake George United Mining and Smelting Company.

The Lake George Mines, Limited, came into existence in August, 1896, when English capital was introduced.

In 1897, J. B. Jaquet and J. A. Watt, Geological Surveyors, made an examination of the deposits, and from their joint report the following extracts are taken:—

"The dominant formations at Captain's Flat are Silurian slates, breccias, &c., which have a meridional strike, and for the most part nearly vertical dip. Upon the western side of the township flat there is a slight western dip, and at the Vanderbilt Mine, which is situated upon the eastern side of the flat, we found an eastern dip; so an anticline would seem to have stretched across the flat at one time, and the Vanderbilt lode upon one hand and the Koh-i-noor and Commodore lode on the other would seem to be on the same geological horizon.

"The lodes, wherever observed by us, are closely comformable with the bedding planes of the country rock. . . . Portions of the lode exhibit a perfect bedded structure, and without doubt represent country rock, which has been slowly replaced by ore *in situ*. In many places no distinct walls occur, and compact ore may be seen, passing by insensible gradations into country rock slightly impregnated with iron pyrites.

"The Commodore shaft—now called Keating's section—is distant 3,300 feet from the Koh-i-noor shaft—now Elliott's section—and between the two there is 1,500 feet of unproved ground. The lode in Elliott's section to the 400-feet level varies from 22 to 30 feet in thickness. In Keating's section it reached a thickness of 40 feet.

"The unaltered sulphide ore consists essentially of a compact, fine-grained mixture of iron pyrites, galena, and zinc blende, with a small quantity of copper pyrites, and a quartzose aluminous gangue. Upon the footwall side of the pyrites lode in Elliott's section, a considerable quantity of barytes is in places associated with the ore. Between the unaltered primary ore and the gossan which caps the lode, there is present a zone of partially oxidised and enriched sulphides, which differ noticeably from these below in containing black oxide of copper (tenorite), and in being on the whole slightly more friable. The upper portions of the gossan have been almost entirely robbed of their copper, lead, and zinc contents by percolating waters, and the enrichment in copper of the unaltered sulphides is probably due to a portion of the metal having been redeposited as black oxide below."

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The chemical composition of an average sample of the ore from the various exposed faces in the great pyritic lode at the 400-feet level in Elliott's section, taken by Messrs. Jaquet and Watt, is revealed in the following analysis by Mr. H. P. White, Assistant Analyst. (Ann. Rept., 1897, p. 21):—

Moisture at 100° C.	0·10
Combined water	0·65
Insol. in acids (gangue)	23·70*
Metallic iron	17·75
,, zinc	14·50
,, lead	8·04
,, copper	1·11
Sulphate of lead ($PbSO_4$)	0·32
Alumina (Al_2O_3)	1·38
Lime (CaO)	0·40
Magnesia (MgO)	0·65
Sulphur trioxide (SO_3)	0·25
Carbonic acid (CO_2)	2·08
Phosphoric acid (P_2O_5)	0·57
Sulphur (S)	27·97
Oxygen and undetermined	0·53
	100·00

* NOTE.—91·35 per cent. of the gangue consists of silica, the remainder containing alumina, magnesia, and alkalies. The silver contents averaged 2 oz. 8 dwt. 14 grs., and the gold 1 dwt. 12 grs. per ton.

The new plant consisted of three blast furnaces of a daily capacity of about 180 tons, and a smaller furnace previously used for concentrating the matte from the above, but since converted into a reducing furnace. Partial pyritic smelting had been adopted after some initial difficulties. In the furnace charge, about 5 per cent. each of flux and fuel only was required.

The following return of the output of Captain's Flat Mines is compiled from the Annual Reports of the Department of Mines and Agriculture:—

Mine.	Year.	Tons of ore.	Silver.		Gold.		Lead.		Copper.	
			oz.	per ton.	oz.	per ton.	tons.	per cent.	tons.	per cent.
				oz.		dwt.				
Koh-i-noor	1887	2,106	45,705	21·3	377	3·5	125	5·9	21	1
,,	1888	Value of product, £6,880—No particulars given.								
,,	1889	4,732	54,511	11·5	660	2·8	215	4·5	70	1·5
Commodore-Vanderbilt	1890	3,986	33,857	9·0	602	3·0	80	2·0	...*	...
Koh-i-noor	1890	4,860	.....	...	823	3·0	(Smelting returns not given)			
Commodore-Vanderbilt	1891	5,657	(Smelting returns not given).							
Lake George S. & G. M. Co. (Late Commodore-Vanderbilt.	1892	7,322	8,824	1·2	156	0·4	...	...	671	9
New Koh-i-noor	1892	11,900	83,050	7·0	783	1·3	...	...	556	5
Lake George S. & G.M. Co.	1893	7,710	60,000	7·8	...	...	...	...	238	3
New Kohinoor	1893	4,264	58,002	13·6	784	3·7	...	...	137	3·2
,,	1894	2,247	17,797	8·0	320	2·8	...	...	94	4·0
,, (gossan)	1894	3,946	.....	...	391	2·0	...	...	...	...*
Lake George United M. & S Co.	1894	2,871	14,667	5·0	106	0·7	...	...	55	2
D do	1895	18,563	137,951	7·0	2,164	2·3	64	0·3	350	1·9
Do do	1896	12,783	69,600	5·4	1,251	1·9	36	0·2	205	1·6

* Gossan. † Battery.

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OUTPUT of the Lake George Mines (Limited), Captain's Flat; supplied by Mr. R. N. Kirk, Sydney Agent for the Lake George Mines (Limited).

Date.	Ore smelted.	Matte produced.	Gold in Matte.	Silver in Matte.	Copper in Matte.	Gold per ton of Ore.	Silver per ton of Ore.	Copper, per cent.	Cost of Production per ton of ore.	Remarks.
	tons.	tons.	oz.	oz.	tons.	oz.	oz.	per cent.	shillings.	
From commencement of operations to stoppage in September, 1898.	79,010·4	2,673·62	5,158·12	190,505·08	885·69	0·065	2·411	1·12	...	The gold and silver contents are included in 16·4 tons of bullion and 6·59 tons of dross, in addition to the matte.
From recommencement of work on 26th November, to 31st December, 1898.	6,351·5	295·56	575·67	15,954·58	92·60	0·099	2·511	1·457	...	
January, 1899	5,312·56	274·20	452·68	13,761·86	76·86	0·085	2·590	1·446	14·78	Total cost of mining, handling, smelting (inclusive of all fluxes and fuels), and general mine expenses.
February, 1899	5,420·18	291·18	369·63	14,712·55	86·93	0·068	2·714	1·603	14·65	,, ,, ,,
March, 1899	5,840·44	326·96	466·95	15,844·88	97·74	0·0799	2·713	1·674	15·55	,, ,, ,, (of which 1s. 2d. is development.)
April, 1899	5,494·05	278·48	370·48	14,453·04	82·66	0·0674	2·63	1·545	15·58	,, ,, ,, (of which 1s. 6d. is development.)
May, 1899	*5,339·67	232·81	330·0	11,606·	61·71	0·0618	2·17	1·55	16·	Including total cost of mining; handling, smelting, development, and general expenses at the mine. Development equalled 2s. per ton.

* In addition, 7·94 tons of precipitates, containing 83·87 per cent. of copper, were produced, valued at £522 16s., at present price of copper. Estimated cost of transport and realisation for the month was 6s. 8d. per ton. The sterling value of the ore, at present price of metals, is £1 8s. 1d. per ton.

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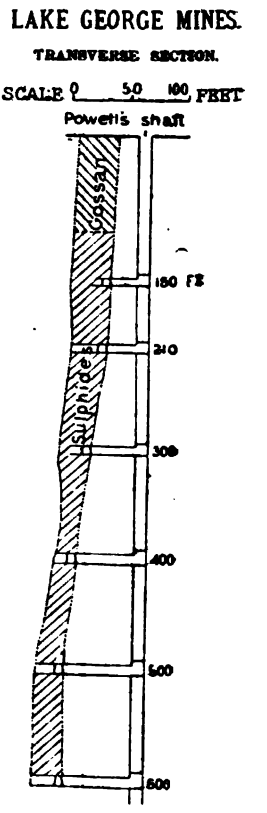
In March, 1899, the Writer inspected the smelting plant and the working levels of the mine for the purpose of recording developments.

The success of operations had been publicly attributed to free use of accumulated stocks of ore, fuel, and fluxes charged to former accounts, also to robbing the richer portions of the lode.

A visit to Captain's Flat was sufficient to dispel the above illusions. Fuel and fluxes were constantly arriving at the smelters, and ore from all levels being continuously delivered from the mine.

The rate of winning (by contract) was too rapid and economical, and the output too great (nearly 2,000 tons per week) to allow of "picking." Stoping was being carried on at the 150, 200, 300, 400, 500, and 600 feet levels in the Koh-i-noor section. Certainly a higher-grade copper ore occurred at 150 feet, and a richer, but refractory, zinciferous silver ore on the east wall of the lode at all levels. The output from these portions of the lode were naturally delivered separately at the ore bins, and judicious blending took place in charging.



The whole operations of Lake George Mines were, perforce, run on such extremely fine lines, owing to the natural poverty of the lode, that no recoverable element of value could be disregarded. Hence, robbing the mine of an undue portion of the richer copper-bearing ore would tend to the exclusion of the richer silver ore, and *vice versâ*. The latter, again, is so refractory, on account of the associated zinc and lead sulphides, as to prohibit profitable separate treatment.

It is impossible for anyone to pass through the working levels of the Koh-i-noor and Commodore sections of the Lake George Mines without a feeling of profound regret for the poverty of a lode which, for size, solidity, and permanence, is rarely equalled.

It was at the time probably the lowest-grade smelting problem ever attacked, the difficulties of which were aggravated by the presence of zinc. Too much credit cannot be given to those who, for a time, skilfully turned it to profitable account without the aid of by-products, and in doing so established a record for treatment and economy, though successful working was to a large extent dependent upon a favourable copper market.

The two classes of lodestuff in the Koh-i-noor workings, designated "copper" or "bulk ore" and "silver ore," owe their classification to the relative

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quantities of copper and silver, which, as will be seen from the following analyses by the Mine Analyst, in either case is exceedingly small:—

	Bulk Ore.	Silver Ore.
Silica	21·55	26·48
Iron	22·26	15·19
Zinc	13·26	14·28
Lead	9·70	8·05
Lime	1·60	...
Sulphur	29·50	27·50
Copper	1·25	·94
Gold	·04 oz. per ton.	·06 oz. per ton.
Silver	1·15 „	3·03 „

The ores were graded into firsts, seconds, and thirds, according to the proportions of zinc in them. Carbonate of lime and a little barytes are also present.

An excellent porous oxide of iron flux was obtained from the gossan outcrop in the Commodore Mine, and copper ore from the Vanderbilt Lode, on tribute.

Special interest naturally attached to the smelting plant, which, like the mining equipment generally, was admirably planned and housed.

Four furnaces were continuously in operation, the blast (hot) being maintained by four Root's Acme Blowers.

Under the method of reduction, the matte was brought up to a marketable grade—30 to 35 per cent. copper—in one operation, thus avoiding the previous extra cost of roasting in attaining this grade.

The composition of a consignment can be judged from the following partial analysis:—

Copper	34·01 per cent.	
Iron	20·85 „	Gold, 1·63 oz. per ton.
Zinc	9·90 „	Silver, 60.00 „
Lead	11·75 „	
Sulphur	22·60 „	

Naturally the proportions of the furnace charges (which were varied to suit the idiosyncrasy of each furnace) were matters of commercial secrecy. The constituents, however, were about 12 cwt. of sulphide ore, with variable quantities of limestone, ironstone (from the Commodore Mine), and slag from the fore-hearths. About 3¾ to 4½ per cent. of carbonaceous fuel (coke) was added to each charge.

Limestone was procured about 3 miles from Captain's Flat, alongside the Bungendore Road.

The silica in the ore is just about sufficient for fluxing requirements.

The composition of the slag discharged over the dump is indicated by the following analyses:—

	(i.)	(ii.)
Silica	34·43 per cent.	37·65 per cent.
Ferric oxide	35·73 „	33·17 „
Calcic oxide	10·86 „	10·40 „
Zinc	12·16 „	14·97 „
Copper	·30 „	·49 „

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The discharge from the furnaces was continuous through fore-hearth separators into slag pots.

"Barring down" was performed about every fifth day to remove the crust formed chiefly of oxide of zinc. The operation required about three hours to complete.

The flue-dust was moulded into bricks, cement being the binding medium used.

Unanderra (South Coast) coke was used in the furnaces.

The plant was lighted by electricity, and telephonic communication was established with all parts of the works, offices, and mine.

At the time of inspection, the old Commodore shaft was being pumped out. The water being charged with copper salts, a primitive attempt was made to precipitate the copper with scrap iron.

A cyanide plant had recently been erected to treat the auriferous gossan capping the southern extension of the lode, which was estimated to average from 2½ to 3 dwt. of gold per ton.

The Lake George Mines furnished an instructive and valuable object lesson on the possibilities of partial pyritic smelting.

Unfortunately the campaign above described did not continue long, the lower levels became too poor for profitable work; copper values depreciated below 1 per cent. with depth, and the better grades at higher levels became exhausted.

In 1900, about 9 tons of precipitate were obtained from the water bailed from one of the old shafts in the oxidised zone.

In 1904 the mineral leases and machinery were purchased by Mr. Channon.

In 1905 a little prospecting was done, mine unwatered, about 4 tons of precipitate obtained with scrap iron.

In 1906 Messrs. Channon and Plumb (owners) employed about ten men for a time prospecting the lode.

In 1907 prospecting operations were continued for a time without favourable results.

Burrowa Division.

Lang's Creek Mine, portion 77, parish Taunton, county King; 5 miles S.E. of Burrowa.—Opened many years ago. Again in 1905; and in 1907 by Messrs. Walker, Garvan, and party.

Strike N. 55° W., dip N. 35° E. at 50°, in quartz-felsite. Length of lode proving about 70 feet, depth 75 feet. Hanging wall well defined. Prospectors two years previously drove a considerable distance south just above water-level, without discovering any further payable ore. Northerly the lode is cut off by a cross joint, and may possibly have been faulted.

Oxidised ore has been stoped out. Winze started in sulphide zone below 70 feet; ore very poor.

The output in 1905 was:—74 tons 14 cwt. 3 qrs., yielding 8 tons 10 cwt. 1 qr. 19 lb. of copper, equal to 11·4 per cent.

Goulburn Division.

Lucky Hit Mine, Merrilla, M.L. 1, parish Gurrunda, county Argyle, about 8 miles from Breadalbane Railway Station, and 20 from Goulburn. Discovered by H. Gillett, August, 1905.

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Main lode.—Strike N. 50° W., dip S. 40° W., 39° to 59°—wavy.

East lode.—Similar strike, dipping at 75°. Distant 78 feet from Main lode. Country slate. Lodestuff—impregnated crushed country along a well-defined and persistent fissure, traceable for a considerable distance north-westerly; but not south-easterly, where it apparently is cut off by a cross joint at the Lucky Hit boundary. (For description of the latter see Merrilla Freehold.)

The Lucky Hit, or Main lode, has been opened by two shafts 100 feet apart, to depths of 93 and 115 feet; and to the south-east by an open cut 64 feet further along the strike.

The East lode was opened by two shafts 30 feet deep and 16 feet apart; and costeens to the south-east.

About 50 feet west of the Main lode an outcrop of carbonate stains in slate had not been opened at time of inspection in May, 1907.

A tunnel from the south-west has since been driven about 400 feet, which will intersect the Main reef at about the level of the bottom of the Main shaft, at an estimated distance of 600 feet. The west lode was cut at about 450 feet, carrying chalcopyrite for a considerable width.

The output to May 3rd, 1907, reached about 130 tons, which realised from 7·8 to 25·9 per cent. of copper at Waratah and Lithgow.

During 1907—95 tons were dispatched for 10 tons 16 cwt. of copper, equal to 11·36 per cent.

Since the beginning of 1908 to the 27th March—the following parcels have been dispatched:—

20 tons, yielding 12·5 per cent. copper, silver 3 oz. 1 dwt., and gold 1 dwt. per ton.

23 tons, yielding 13 per cent. copper, and similar amounts of gold and silver.

These consignments have all been from the carbonate or oxidised zone in both lodes. A little very-sparsely distributed copper sulphide occurs in the Main shaft at 115 feet.

In the 93-feet, or Underlay shaft, a vug was encountered (30 feet x 30 feet x 2 feet), below which to 93 feet no ore occurred.

Channel at bottom reddened, upper part of vug filled with pug.

The workable lens proved in the East shaft was 35 feet long and 5 feet in the widest part.

Major's Creek Division.

Major's Creek.—Copper ore occurs in Rigby's Reef, about 1½ miles north-west of Major's Creek township; but gold is the chief element of value. Two and a half hundredweight of stone from the 64-feet level, sampled and assayed at the Australian Smelting Company's Works, Dapto, yielded:—

Gold	19 dwt. per ton.
Silver	26 oz. „
Copper	14½ per cent.
Antimony	5 „

Thirty tons subsequently forwarded yielded only 4 dwt. of gold and 9 oz. of silver per ton, and 3 per cent. of copper. The unoxidised ore consists of iron and copper pyrites and fahlerz.

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SOUTHERN MINING DISTRICT—*continued.*

Burrowa Division.

Mayfield Copper Mine, Rye Park, about 17 miles east of Burrowa.—This mine was opened in 1895. Fifty tons of ore raised yielded 9 tons of copper, valued at £360. Shaft, 125 feet deep; lode, 2 ft. 6 in. thick. In 1896 the mine was being developed; no output recorded. In 1897 worked by a party of four; output valued at £1,605. The following parcels of ore were treated at the English and Australian Smelting Works, Waratah:—

Tons	cwt.	Yield.	Tons	cwt.	Yield.
13	13	12½ per cent. copper.	4	10	10½ per cent copper.
2	10	23 „ „	3	19	15¾ „ „
5	1	9⅝ „ „	10	8	15¼ „ „
9	18	15½ „ „	5	0	32 „ „

Goulburn Division.

Merrilla.—Costley and party's prospecting area, 40 acres, adjoining M.L. 4, on the south, parish Gurrunda, county Argyle.—Shaft 115 feet, sunk in pug and breccia, made ground; water heavy, standing at 75 feet from surface. Evidently old valley filled in with alluvial and detritus from bounding ridges. Similar breccia seen on banks of Heffron's Creek, lying flat on cleavage of slate. In the pug—which swells up in bottom of shaft—nodules of secondary pyrites occur; also fine-grained granular pyrites.

In crosscut east at 50-feet level, about 4 feet of soft granular gossan occurs, carrying crystals of carbonate of lead, and in a lesser degree carbonate of copper. A similar bunch seen in west end of shaft. The ferruginous breccia occurs on both sides of the gossan. The lead and copper carbonates appear to be of secondary origin, probably from solution, unless representative of altered boulders of lodestuff.

A sample of the breccia and ore exposed for 17 feet in shaft and crosscut yielded:—

No. 07-3459	Gold	a trace per ton.
	Silver	11 dwt. 23 grs. per ton.
	Copper	less than 0·25 per cent.
	Lead	1·85 „

Sample 07-3460 (representing the metalliferous portion only) yielded:—

Gold	a trace per ton.
Silver	1 oz. 8 dwt. 7 grs. per ton.
Copper	0·35 per cent.
Lead	2·88 „

Merrilla Copper Mine, parish Gurrunda, county Argyle, adjoining the Lucky Hit Mine on the north-west.—The Lucky Hit Main lode has been traced for a mile or more, though no important discoveries have yet been made in it outside of the two mentioned.

The Merrilla mine was opened by W. Hanley in May, 1906, taken over by a syndicate, and subsequently by the Merrilla Copper Mining Company.

The lode, as in the Lucky Hit, consists of an impregnated belt of crushed slate without defined walls. It has been opened up by three shafts and a tunnel. The shafts being 30 feet, 40 feet, and 86 feet deep; and the tunnel 80 feet long. The Main—86 feet—shaft is sunk in a valley 130 feet below

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the surface level of the furthest north-western shaft. These openings extend for a distance of about 20 chains along the outcrop, copper carbonate being visible in the shallow levels, sulphides below.

The Main (86 feet) shaft has been sunk mostly on the underlay of the lode—which is to S. 40° W. at 55°. Levels have been driven 20 feet south-easterly at 55 feet, and 20 feet north-westerly at 60 feet.

About 10 feet wide of impregnated country is exposed in this shaft, carrying native copper, cuprite, and probably melaconite, down to about 50 feet. Then sulphides, consisting of pyrite and chalcocite (subsulphide of copper) from enrichment. At the lowest level the sulphides are fairly solid.

A greasy joint occurs near footwall simulating a true wall, but ore occurs about 1 foot behind it; the joint probably being more recent than the metallic sulphides. The impregnated slate is more or less corrugated on a minor scale. Quartz strings and lenses occur but rarely in the lodestuff; but a large defined quartz reef outcrops a few feet west on a persistent south-east strike.

The nature of the enriched ore at 86 feet is shown in the following partial analysis:—

No. 07-3464—	Copper	1·90 per cent.
	Lead	2·81 „
	Silica	22·85 „
	Gold	a trace
	Silver	6 oz. 3 dwt. 1 gr. per ton

At 40 feet in No. 2 shaft similar enriched (subsulphide) ore occurs, but not so solid as in No. 1.

The crosscut tunnel is of little importance as it intersects the lode only a few feet below the crop.

According to the Annual Report of the Department of Mines, 1907, p. 54, about 100 tons of ore were sent to market which yielded a profit of £120.

The mine was disposed of to a Melbourne syndicate, which, however, failed to fulfil engagements.

Taralga Division.

Mount Bannaby Copper Mine, portion 177, parish Bannaby, county Argyle, 12 miles from Taralga; discovered by A. Potter.—Depth of proving, 40 feet. Lodestuff quartz with a little copper and iron pyrites.

Braidwood Division.

Mount Fisher Copper Lode, about ¼ mile from old Mulloon Copper Mine, Bungendore district.—Shaft, 170 feet at beginning of 1907. Lode reported to be 7 feet wide at 140 feet, thin at 170 feet.

Major's Creek Division.

Mount Hope Mine (known also as Eureka and Snobs), P.M.L. 94, parish Elrington, county St. Vincent, near Major's Creek, Braidwood.—Inspector G. Smith reported in 1903:—Quartz reef containing pyrites with small quantities of chalcopyrite and fahlerz. Thickness averages about 4 inches. Strike E. and W., slight dip N.; depth proved 375 feet, length 600 feet.

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The picked ore yields about 3 oz. of gold per ton, 2 oz. of silver, and 2 per cent. copper. The seconds—about 3 dwt. of gold and the same percentage of copper.

Braidwood Division.

Mulloon Copper Mine, 30 miles north-west of Braidwood, and 10 miles south-west of Boro.—Mr. James McDonald, of Braidwood, supplied the following particulars (1898) of the above mine, which is situated on the property of Messrs. Scott:—"This mine was worked some twenty-five years ago, and a furnace was erected for smelting purposes, but prematurely, as little prospecting had been done. The shaft was down 100 feet. The ore consisted of grey sulphide, assaying very high, but occurring only in bunches. Both gold and silver were associated with the copper. By the time the above work had been completed the capital was understood to be exhausted, and the enterprise was abandoned."

A trial parcel of copper ore from Boro, treated by the English and Australian Smelting Co. at Newcastle in 1873, doubtless came from this mine, viz., 1 ton 11 cwt.; yield, 12⅞ per cent. of copper.

Inspection by the Writer in 1898 disclosed a considerable amount of work, but all very close together. The furnace, for some unaccountable reason, was erected some miles from the mine. The timbering of the shafts had all been destroyed by fire, so that inspection was not possible. Limestone is adjacent to the mine.

Opposite the Mulloon mine, on the south side of Mulloon Creek, McLaughlin and party were working the adjoining property, which was opened at the same time as the Mulloon. Country, slate; lode-strike, east and west, but wavy, following bedding of country. In an open cut close to the creek a wide body of copper ore is exposed without defined walls. A little good ore is visible in the old stopes. No particulars are available of the results of the early workings.

The Mulloon mine was taken on tribute by two miners in 1906, who despatched 5½ tons of ore to Lithgow. Veins very narrow. Ore reported to have yielded 25 per cent. of copper.

Also worked on tribute in 1907. Shaft 175 feet deep. Vein 4 inches thick; 10 tons averaged 20 per cent. of copper.

Goulburn Division.

Mummell Copper Mine.—In the *Australian Mining Standard*, December 17th, 1896, it was reported that a lode had been struck in this mine at a depth of 100 feet, having a thickness of 1 foot, according to a previous issue. Assays $\frac{120 \text{ to } 120}{80}$ from this locality yielded from 28 to 35 per cent. of copper, the ore being glance.

Under date of December 8th, 1898, J. B. Jaquet reported that the Mummell Copper Mine occurs in R. Lamb's property, about 10 miles west of Goulburn, in slate country. The lode, from 2 to 13 feet wide, dips west at an angle of about 45°. The lode material consists of country rock, silicified and otherwise altered, with veins and nests of copper and iron pyrites, with a little galena and blende. The ore, on the whole, is very silicious. Some rich carbonate ore was obtained near the surface. About 70 tons have been sent away to various smelting works for treatment, yielding, according

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to Mr. Lamb, about 17 per cent. of copper. The lode has been proved to a depth of 70 feet by a shaft, and short drives have been driven along its course at that level.

A shaft to cut the lode on the underlay has been sunk 100 feet, at a distance of about 60 yards from the outcrop, naturally without cutting the lode at that level.

Murrumbidgee River Basin.—The Rev. W. B. Clarke, in a report[1] dated June 1st, 1852, wrote as follows of portion of this area:—

"The whole basin of the Murrumbidgee, from near Bullanamang to the junction of the Queanbeyan River, and even as far as the junction of the Yass and Goodradigbee Rivers (as, for instance, at Good Hope), exhibit not only metalliferous formations, but in some places lodes of lead, copper, and iron; and there can be no question that in some of these localities metallurgical operations may be profitably conducted. The association of abundance of limestone with these deposits is quite in accordance with similar associations in the mining countries of the European and American continents. The quartz porphyry, which occupies so large an area in the Murrumbidgee basin, is in Europe one of the most important and prolific sources of mineral wealth.

"Judging from what I have seen of the ores and vein-stuff of the copper-lodes of Pudman Creek, on the Burrowa branch of the Lachlan, I presume that the Murrumbidgee deposits are continuous to the north, probably branching at intervals along the 149th meridian, to a junction with the copper and lead districts of the Belubula and Macquarie.

"A further confirmation of the metalliferous nature of the region along the 149th meridian is shown by the lodes of copper and lead about Quidong and the traces of similar ores on the McLaughlin.

"Near the junction of the Queanbeyan and Murrumbidgee Rivers the copper is found occasionally in the native state—*i.e.*, pure—in flakes adhering to the laminæ of the granite rock, which is traversed by the lodes. Near Yarralumla I saw somewhat similar examples."

Binalong Division.

Murrumbidgee Copper Mine, mineral lease, 40 acres, parish of Birrama, county Harden.—Geological Surveyor W. Anderson, who examined this mine in connection with the Prospecting Vote (P.B. $\frac{s}{98}\frac{1}{4}$) reported that an underlay shaft had been sunk 125 feet in a well-defined lode in granite, and several levels driven. The lodestuff was reported to consist chiefly of copper pyrites; but, judging from samples shown the Writer, the bulk of it was magnetic iron oxide. Aid was granted to continue prospecting, but without satisfactory results.

Reopened in 1907, and shaft unwatered for a brief period.

Frogmore Division.

Pride of Frogmore Mine.—In Sheedy's land, adjoining Frogmore Mine on west side. Worked at same date as the latter, by Mr. S. L. Bensusan. Smelters erected—no particulars as to output. About 2,500 tons of slag in

[1] Southern Goldfields, pp. 236-7.

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dump, reported by Mr. J. F. Carey to assay 1·75 per cent. of copper. Also about 400 tons of ore at grass from early operations; averaging 3·72 per cent. of copper, and 10 per cent. iron, according to the same authority.

Mine not now open to inspection. Reported that the old main shaft was in a lens of ore which dipped south from the shaft at 210 feet. Average size of lens, 66 feet long by 4 feet wide. Oxidised ores to about 85 feet, then sulphides. Apparently no prospecting beyond stopes. Ore reported to have been left at south end from 90 feet up—18 inches to 24 inches wide. Strike of lode, N. and S.

Country, slate and crushed quartzite. Water standing at about 30 feet from surface in old workings.

Taken under option by Mr. F. Drake, in 1907, who sank a shaft 340 feet south to a depth of 100 feet and crosscut west 5 feet, east 26 feet. The latter cut 12 to 18 inches of gossan without trace of copper.

Yass Division.

Red Hill Mine, about 14 miles from Yass, near the head of the Burrowa River.—According to Mr. A. McCallum, of Yass, this mine was being worked in 1906 for gold and copper. In sinking the main shaft (110 feet), ironstone was passed through for 40 feet, then copper carbonates to 75 feet. At 110 feet sulphide ore was being tested. An east and west crosscut for 30 feet reveals no walls.

Frogmore Division.

Sapling Gully, about 6 chains south of Water Reserve on Narraba Creek, D. Flannery's land, 25 miles north of Burrowa, parish Yundas, county Monteagle.—Inspector J. James reported (P.B. $\frac{2}{3}\frac{3}{7}\frac{0}{0}$) a lode striking N. 20° W., dip N. 70° E., Patches of good ore have been discovered along this line for a distance of 1½ miles; the lode being 2 feet wide in places.

Aided to sink from 23 to 75 feet.

Later the Warden's Clerk reported a good deal of water to contend with. Good ore decreasing; pyrites with splashes of yellow ore coming in shaft.

Yass Division.

Sapling Point Creek, near north-west corner, portion 131, parish Borambola, county Murray, about 12 miles south of Yass.—Geological Surveyor L. F. Harper reports that two leases for copper were taken up at this site in 1887, but little work was done. Several small veins of quartz carrying copper and iron pyrites are visible, and oxidation gave rise to carbonate stainings on the surface of the porphyry country. Indications unfavourable.

Goulburn Division.

Sassafras.—Inspector D. Milne reported—" On the Shoalhaven River, about 15 miles from Sassafras, Sievewright and party discovered a copper lode showing on the south side of a deep gorge. The formation can be seen for a distance of about 500 feet, cutting diagonally across the face of a gorge, varying in thickness from 1 to 10 feet, consisting of bands of ore composed of copper pyrites, galena, zincblende, iron pyrites, and slate rock. Owing to the almost inaccessible position, it will require a very heavy outlay to remove the ore to a suitable site for treatment." (Ann. Rept., 1907, p. 81).

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Talwong Mine, Shoalhaven River, near Bungonia.

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Shoalhaven River Gorge near Talwong Mine.

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Southern Mining District.—*continued.*

Binalong Division.

Spion Kop Lode, 2 miles N., 20° E. from Goondah Railway Station, and 6 from Bowning; portion 640, parish Illalong, county Harden. Discovered by M. Cotter about 1905.—Strike N. 32° W., dip S. 58° W., at 78°, in quartz and felspar porphyry.

Width of ore channel, 2 ft. 6 in.; walls well-defined. Ore mostly on walls, occasionally in centre, greatest thickness about 1 foot, usually a few inches; patchy in mode of occurrence. Length of lens, 50 to 60 feet. Ore consists of galena with a little copper and iron pyrites. Proved for a length of 250 feet by three shafts, ranging in depth at time of inspection in 1907, from 33 to 55 feet. Main shaft since deepened to 80 feet, and aided from Prospecting Vote.

Twelve tons of gossan from 10-feet level yielded 16 dwts. of gold, and 11 oz. of silver per ton. Copper and lead not ascertained

Average samples of the "firsts," stacked at surface, and the "seconds," dressed from the former, yielded the following results:—

Assay No.	Description.	Copper per cent.	Lead per cent.	Gold per ton.	Silver per ton.
					oz. dwt. grs.
07-6717 ...	"Firsts" from heap at grass ..	2·35	20·20	Trace.....	5 8 21
.....	"Seconds" from heap at grass...	2·00	.....	3 dwt. ...	7 0 0

Nowra Division.

Talwong Mine, M.Ls 1 to 4, parish Borimbodal, county St. Vincent.—Discovered by John Sivewright about 1904, in a precipitous gorge of the Shoalhaven River Valley, about 9 miles S.S.E. of Marulan Railway Station. The river channel has been excavated from 1,500 to 1,600 feet deep in quartzites and slates of Ordovician age, at least in part. The Talwong lode is strong and well-defined, cutting across the stratification. The ores are a complex mixture of mispickel, stannine, chalcopyrite, and galena. (For further particulars, see page 413.)

Yalwal Division.

Touga Copper Mine, parish Touga, county St. Vincent, about 10 miles from Nerriga, in a northerly direction.—The first record of copper-ore in this locality appears in the Parliamentary Votes and Proceedings, 1872, vol. ii, p. 1021, in the form of a petition *re* a copper lode on the west side of Togra(?) Creek, Braidwood district, north and south of the crossing-place at Querera Station, which, petitioners averred, had been wrongfully taken up by others who had learned of its existence from one of the discoverers.

In 1896 J. B. Jaquet visited the locality, and reported as follows:—"The geological formations represented are horizontally bedded sandstone belonging to the Devonian or Upper Marine Series, and much indurated slates and quartzites of Silurian age. The copper lodes are confined to the slates, &c. The outcrop of a copper lode has been exposed for a distance of 36 feet, at a point distant about 100 yards below the junction

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of Touga and Quera Creeks. The lode is about 2 ft. 6 in. thick. It does not appear to have defined walls, but, like many other deposits of this metal, seems to consist of country more or less impregnated with quartz and copper pyrites.

"About 200 yards north of the lode last described, another one has been discovered, and traced for several chains upon the surface. It is about 1 foot wide A picked sample yielded 13·16 per cent. of copper, and silver at the rate of 1 oz. 12 dwt. per ton.

"A little south of the junction of the two creeks the outcrop of a copper lode can be seen running up the precipitous bank of Touga Creek."

Mr. J. Donohue, who worked in the mine, stated that the prospecting shaft was sunk 40 feet vertical and 40 feet on the underlay, and a level driven 80 feet on the course of the lode. No stoping was done. The only ore raised was from the sinking and driving. The copper deposits were very patchy. The ore was chiefly grey ore. A little native copper was obtained from the shaft.

Major's Creek Division.

United Miners', Major's Creek, parish Elrington, county St. Vincent, in private land.—Quartz vein containing pyrites, worked for gold; containing about 2½ per cent. of copper.

Burrowa Division.

Wallah Wallah Copper Mine, parish Rugby, county King.—Opened about 1846, according to the late Mr. J. K. Hume. W. Anderson, in 1891, reported that this mine was opened over forty years prior to his visit to the locality, some good ore being obtained from it. J. B. Jaquet states that the lode occurs in granite about 1½ mile from the junction with slates in the parish of Ware. It has a general north and south strike. The outcrop can be traced for a considerable distance, its width being about 4 feet. A good deal of carbonate ore can be seen where the lode is exposed.

Mr. I. Stevenson, of Burrowa, stated that no ore was smelted or sent from the mine during the early workings, but that it was stacked on the surface. Many years after, it was despatched to smelting works, but the result is not known.

Yass Division.

Woolgarlo Mine, Yass River, 17 miles from Yass.—This mine is situated directly opposite the Good Hope Mine. Several lodes occur on the Woolgarlo property, but none have yet been proved workable. Some contain a little copper ore. The main lead (galena) lode has no defined walls. In 1870 a concentrating and smelting plant for lead was erected on this property; but being placed too close to the river bank, was washed away in the first flood. The prospectus of the Woolgarlo Lead-mining Company (Limited) was issued on 16th March, 1867.

Fluor-spar forms the gangue of lead ore, and is evidently in considerable quantity.

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TAMBAROORA AND TURON MINING DISTRICT.

Stuart Town Division.

A1 Mine, Tinby, near Yeoval, south-east corner portion 35, parish Obley, county Gordon.—Held under authority to enter. Discovered by W. Blatch in 1903. Work started April, 1907. Strike of lode N. 25° W., dip S. 65° W. at 83°. Development to 12th December, 1907:—Shaft 90 feet, sulphide of copper struck at 60 feet. Lode formation, 2 to 4 feet wide. About 2 feet of ore at bottom on north end of shaft; traces only in south. Not solid or defined; irregular, in granite country. Apparent walls at 90 feet, but may not be true. Ore at higher level passing into footwall, gossan into hanging wall.

Ore consists of chalcopyrite and magnetite, the latter somewhat specular in appearance.

An average sample of dressed ore at surface yielded:—

No. 07–8009—Copper			12·37 per cent.
Zinc	less than	0·1	„
Gold			a few grains per ton.
Silver			17 dwt. 10 grs. „

An average of the "fines" from the above, yielded:—

No. 07–8010—Copper			4·05 per cent.
Zinc	less than	0·1	„
Gold			1 dwt. 2 grs. per ton.
Silver			16 dwt. 8 grs. „

Rylstone Division.

Cheshire Copper Mine, 3 miles south of Cudgegong.—The first mention of copper ore in this locality occurs in a report by the Rev. W. B. Clarke, dated 1st October, 1852. "Indications of lead (galena) and copper occur in the quartz lodes of the ranges upon the upper portion of Lawson's Creek" (15 miles from Cudgegong).

In 1882, prospecting operations were carried on by C. Knoblanche (about 6 miles from the Ilford Station on the Mudgee railway), the shaft being about 75 feet in depth. Carbonates of copper occur at surface, sulphides at 40 feet or 50 feet. The lode has a thickness of about 2 feet, N. and S. strike, and westerly dip.

In 1883, the Mining Registrar reported that a large staff of men were employed, the shaft being down 120 feet, at which depth levels were being driven, the lode being 6 feet wide.

In 1885 the company in possession suspended work, and subsequently let the mine on tribute, but work ceased entirely in 1886.

In 1897 the mine, under the name of the Rhobodah, was bailed out by I. Wall, but no work was done, as the lode was not deemed equal to representations. It does not appear that any ore was ever despatched.

Cyclops Copper Mine, Lower Tinby, near Yeoval, portion 93, parish Obley, county Gordon.—Opened about thirty years ago to a slight extent. One hundred acres now held under option from trustees of Thos. McCulloch's estate.

Several ore bodies occur, two of which have received most attention.

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No. 1 shaft has been sunk 70 feet on a vein, striking N. 30° W., and dipping S. 60° W. at 71°, carrying copper pyrites. Width about 1 ft. to 1 ft. 6 in. at bottom, in very hard country. Greatest reported width about 3 feet.

About 10½ chains S. 70° W. No. 2 shaft has been sunk 60 feet on a vein, striking N. 10° W. Between the shafts a shallow shaft and trench expose other veins showing copper stains.

No. 2 shaft has been driven 40 feet south at the 50-feet level, at the end of the drive the ore is being followed down on a southern pitch. Underhand stoping was proceeding from this level. A sample of the dressed ore from the stope yielded the following results:—

No. 07-8011—Copper	.....	6·52 per cent.
Gold	.....	a few grains per ton.
Silver	.....	10 dwt. 21 grs. „

The total output from May, 1907, to January 17th, 1908, was 40 tons, averaging 11 per cent. of copper and 1 dwt. of gold and 3 oz. of silver per ton.

Dolcoath Lode, on J. Whittaker's private land, parish Obley, county Gordon, near Yeoval.—A new discovery of copper ore in granite; opened about 8 feet at time of inspection in 1907. Lodestuff carries a little carbonate and sulphide of copper, with magnetic iron of a character resembling specular ore. A width of lodestuff 6 inches to 18 inches showing in 8-feet shaft just started. Strike N. 25° W.

An average sample yielded:—

No. 07-8008—Copper	.....	3·55 per cent.
Gold	.....	a few grains per ton.
Silver	.....	6 dwt. 13 grs. „

About 5 chains south-east similar copper stains show at surface.

Goodrich Copper Mine, formerly known as Buckenbah, Gordon, and Yeoval.—The Goodrich Mine is situated about 4½ miles from the village of Yeoval. The ore occurs in quartz veins in granite, and consists of chalcopyrite, magnetite, and a little molybdenite and gold and silver. The mine was worked as an open quarry to a depth of 120 feet by a width of about 70 feet.

According to the late Mr. Gibson, of Yeoval, the lode was discovered about 1868, and was shortly afterwards taken up by Messrs. Wynne, Gibson, and party, who worked it as a gold mine for twelve or fourteen months, extracting in that period 800 tons of stone, which yielded by battery treatment 1.504 oz. of gold, of the value of 58s. 9d. per ounce only, on account of the large admixture of silver.

At surface the deposit presented the appearance of a small cone of brown iron ore in granite. From this point the gold-bearing quartz veins dipped away in annular form, so that as the excavation proceeded the central cone was left standing. The party worked the auriferous ring about 16 feet wide to a depth of 28 feet, when copper pyrites were encountered, which rendered their battery treatment ineffective and influenced them to dispose of the property to a syndicate, who erected furnaces under the direction of Mr. Lewis Lloyd, to treat the copper ore. The syndicate, in blasting away the central cone, are reported to have obtained a good bunch of workable ore.

Mr. Gibson stated that smelting was continued for about seven years. The furnaces—two reducing and one refining—were erected on the Little River, about three-quarters of a mile from the mine. The ore was cobbed and

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picked by hand, the fines being jigged. The refined copper is reported to have realised a high price, because as subsequent assays proved, of the quantity of gold concentrated in it—equal to 3 oz. 17 dwt. 10 grs. per ton by assay. It is, however, probable, judging from the experience of Cobar, that the quality of the copper alone affected the sales.

After Mr. Lloyd's supervision terminated, mining was carried on for a further period of two years under Mr. Gibson's management, who stated that the output averaged about 8½ tons of copper and 130 oz. of gold per month. Later the mine was purchased by Mr. J. Veitch, who worked it for gold only, but afterwards attempted, unsuccessfully, to smelt the cupriferous concentrates and tailings.

The quarry-like opening during the above operations assumed its present dimensions—about 75 feet by 60 feet by 150 feet, though the centre was not removed lower than 70 feet.

In 1886, Chief Inspector Slee reported that the monthly crushings under Mr. Veitch's management amounted to about 150 tons, yielding from 3 to 7 dwt. of gold per ton. The crushing plant consisted of a 20-head stamper battery, with grinders and concentrators constructed by the owner; a tramway of about three-quarters of a mile in length connected the mine and the crushing machinery. After extraction of the free gold by battery treatment, the copper ore was roughly concentrated, over 1,000 tons of the latter being stacked at the date of inspection, which the owner estimated by assay to contain 9 per cent. of copper, and 10 dwt. of gold, and 2 oz. of silver per ton.

After a fatal accident to a miner the open quarry workings were abandoned, and work ceased so far as winning ore was concerned. Subsequently a syndicate secured the property, on a purchasing option, and sank a shaft 80 feet in the country about 50 feet from the side of the quarry, and then abandoned operations before anything definite had been accomplished.

A large amount of lean ore was at grass, but the presence of copper precluded advantage being taken of cheap extraction of the gold by cyanidation. At the bottom, 4 per cent. concentrating ore was reported. Pillars of ore had been left in the workings, and veins—hard and firmly attached to the country—were to be seen in the sides of the open quarry, dipping flatly away from the opening.

The mine was again held in 1898, and the workings unwatered; but little development work was done.

About 1903 it was reopened by the present Goodrich Proprietary Company from the main or new shaft—then 80 feet deep—in country about 200 feet from the open quarry workings. At time of inspection by the Writer in 1908, strong poppet heads had been erected and the shaft deepened to 300 feet. At 200 feet a crosscut south-south-east for 70 feet cut the lode under the quarry, apparently at its strongest point—about 10 feet wide. A level was driven for about 200 feet along its strike in both directions; the ore lens tapered to mere blotches and strings in the granite.

A rise from the crosscut in the ore body connects with the bottom of the open workings at about 120 feet from surface.

It is intended to again crosscut at 300 feet. Its slight eastern dip is expected to bring the lode nearer the shaft at that depth.

So far the country has not been crosscut west, and as ore occurs east of the lode, it may also extend in the opposite direction.

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It is unlikely, owing to extreme hardness of the country, that any but the solid ore makes will pay for extraction.

From the crosscut and the rise considerable paddocks of firsts and seconds are at grass. Segregated masses of pure chalcopyrite occasionally occur; a 10-ton parcel of picked ore of this class yielded 23 per cent. of copper.

The ore contains a considerable proportion of magnetic iron oxide, which at first glance might readily be mistaken for zinc blende, from which the ore is very free. Quartz is also freely associated with the ore.

An interesting feature of the deposit is the occurrence of isolated patches of quartz and copper ore in the solid granite, apparently unconnected with the lode.

An average sample of firsts, paddocked at surface, yielded:—

No. 07-8007—Copper	.....	3·35 per cent.
Zinc	.....	0·10 „
Iron	.....	11·90 „
Silica	.....	61·58 „
Gold	.....	3 dwt. 6 grs. per ton.
Silver	.....	9 „ 19 „ „

In the treatment of this ore concentration will be needful, and should prove clean and effective.

One mile south of Goodrich Mine, the Buckenbar Copper-mining Syndicate sank 120 feet in a copper lode, the ore being disposed of to the Goodrich smelters, but the quantity was not large.

At Dilga Creek, 6 miles south of Goodrich, poor copper ore occurs, much mixed with other sulphides. (For other occurrences in the neighbourhood, *see* Tinby Hill.)

Lady Lizzie Mine, about 1 mile north of Yeoval, parish Obley, county Gordon, in Reserve 28,321.—Strike N. 20° W. in granite with diorite intrusions. Several outcrops superficially opened, revealing a little copper carbonates and sulphides in granite associated with quartz.

Aided to sink from 56 feet to 106 feet.

At 54 feet the vein material varies from 8 inches to 18 inches wide in hard country. An average sample of the dressed ore gave:—

No. 07-8005—Copper	.....	6·07 per cent.
Gold	.....	a few grains per ton.
Silver	.....	6 dwt. 13 grs. „

Three tons previously despatched to Lithgow yielded 3½ per cent. copper. Not promising.

Mount Rose (late Frog's Hollow), reserve 45, parish Bolderogery, county Gordon, near N.W. corner of portion 23, near Goodrich Mine.—Opened originally by P. Brown, about 1872. Several parallel lines striking about N. 55° W., dip S. 35° W. at 45° in granite. Consisting chiefly of copper-stained garnet rock. Two lines, about 145 feet apart, opened by shafts 75 feet and 45 feet; recently the latter received attention, being deepened to its present depth. Matrix mostly garnet, with a little copper carbonate and sulphides of the following grade:—

No. 07-8006—Copper	.....	5·47 per cent.
Gold	.....	1 dwt. 2 grs. per ton.
Silver	.....	1 oz. 6 dwt. 3 grs. per ton.

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TAMBAROORA AND TURON MINING DISTRICT—*continued.*

Sofala Division.

Sofala, G.L. 8, parish Dulabree, county Roxburgh, Tobin's Oaky Creek 8 miles east of Sofala.—Geological Surveyor Harper reported (11th March, 1908) a quartz reef with copper pyrites near junction of intrusive diorite, with Devonian quartzites and conglomerates. Several shafts were sunk some years ago, prospecting for gold. Present prospectors, in a 12-feet shaft, had 2 feet of quartz containing 5 to 6 per cent. of copper.

Stuart Town Division.

Tinby Hill, about 1 mile northerly from Yeoval, and about 4 from the Goodrich Copper Mine.—In the same belt of granite country as the latter, copper ore of poor quality has been prospected at Tinby Hill. On the hill and on its slopes stains of copper carbonates occur freely distributed, but rarely forming more than mere colourations in the joints and cracks of the granite. Under Government aid a shaft was sunk about 60 feet in a large body of quartz, stained with carbonates, in which a little gold occurs, but not in payable quantity. More recently a syndicate prospected on the top of the low hill, along a small joint which carries copper pyrites, concentrated in ¼ to ½ inch skins on the faces of the joint. Little quartz shows at this point, but farther south at the end of the hill, old workings reveal a quartz reef about 10 inches thick, lightly copper-stained. A short distance west, another line of jointing shows faint stains of copper. The strike of both joints is about N. 10° W. A shaft has been sunk 28 feet on the first mentioned with hard country at bottom. As copper lodes, these are of no value, and the gold contents are not in payable quantities.

Viles' Lode, portion 29, parish Bolderogery, county Gordon.—Worked when Goodrich Smelting Works were running; ore from it sent to latter. Strike approximately N. and S. in granite. Opened by three shafts (not open to inspection). "Seconds" rejected at surface—very silicious. Length of proving about 4 chains; depth, 28 to 80 feet.(?) Lode apparently of fair size—judging by refuse. A little sulphides present in quartz.

Yeoval, portion 23A, parish Obley, county Gordon. Copper carbonates staining granite and quartz in several places in this portion. Several shafts and open cuts, all revealing stained country, but nothing defined. On principal outcrop, aid granted to Williams and Taylor to sink to 80 feet level; not fully worked out. Site abandoned.

North Buckinbar Prospecting Claim, portion 99, parish Obley.—Opened in April, 1907. From surface to 40 feet a few leaders showing slight stains of copper carbonates only. Shaft 72 feet; crosscut at 50 feet for 31 feet west, in country.

Copper stains also occur about 10 chains southerly.

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TUMUT AND ADELONG MINING DISTRICT.

Tumut Division.

Adjungbilly Creek.—Copper ores occur sparingly in the serpentine belt which trends from Muttama south-easterly to Lac-ma-lac and beyond. Adjungbilly Creek crosses this belt just south of Mount Lightning, near the Murrumbidgee River. In Tea-tree Gully, about three-quarters of a mile south of the creek, native copper has been found. On the north fall of Mount Lightning copper ores outcropped; but a few feet of sinking revealed the superficial character of the carbonate stainings. At Brungle, Wyangle, and near Kangaroo Mount, in the same belt, copper ores occur.

Queanbeyan Division.

Balconnel Gold Mine, parish Weetangra, county Murray, close to junction of Molonglo and Murrumbidgee Rivers.

Inspector Godfrey reported (P.B. $\frac{22}{10}\frac{1}{10}\frac{2}{2}$) a quartz lode containing sulphides of lead and copper. Strike, S. 40° E.; dip, S. 50° W. at about 75°.

Opened by tunnel under bluff 14 feet high. Veins of galena worked here previously. Quartz reef 1 foot 6 in. thick, cut at 14 feet in tunnel, carrying galena and chalcopyrite.

Aid granted to sink a winze 50 feet. Tunnel continued to 55 feet. A leader 4 in. wide carrying pyrites and galena cut at 36 feet. Aided to continue 100 feet in tunnel. Nothing of value disclosed.

Delegate Division.

Belmore Copper Mine, Quidong, Monaro.—In an official report, dated 6th February, 1852, the Rev. W. B. Clarke wrote as follows of the site of this subsequently-opened mine:—

"As the extent of the limestone country is considerable, and its aspect is such as to lead to the belief that it is metalliferous, being bare of grass and extremely ferruginous in hue, occasioned by the presence of cupriferous iron-stone. I think it is not improbable that more than an insignificant amount of gold may be discovered hereafter, but the value of the locality appears to me to rest upon other considerations.

"Exactly where the largest auriferous hollows occur, veins of copper and lead, several feet in width, make their appearance in the limestone, and pass through to the face of the cliff in a south-east direction. The veinstone is chiefly barytes, and the ores are chiefly fibrous and earthy green carbonates and yellow and iridescent sulphurets of copper, with interspersed crystallised sulphurets of lead. The latter stands out of the face of the limestone in independent crystals.

"As copper and lead exist in various parts of this tract of country, it is extremely probable that a mining field may be here profitably worked."

In Mr. Clarke's collection at the Paris Exhibition of 1855 were specimens of copper and lead ores in limestone, from "Merinoo, Deleget River," which, doubtless, corresponds with the above locality.

In December, 1868, the prospectus of the Belmore Freehold Silver and Lead Mining Company, Bombala, was issued. Judging from the appearance of the locality when visited by the Writer in 1897, a considerable amount of prospecting for copper must have followed the formation of the company. A large amount of work was done in sinking and driving on the east side of

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the Quidong River, in country revealing surface indications of copper, and abundant oxide of iron, the latter resulting from oxidation of pyrites, which, in its unaltered condition, is very plentiful in the spoil from the deepest shafts. Another source of the prevalent iron oxide which colours the rocks and soil of the neighbourhood, is the original precipitation of iron salts by the abundant organic remains (Upper Silurian) in the strata, which consist of mudstone, sandstones, and limestone. The precipitates have been converted into oxides, as weathering and denudation exposed the fossiliferous layers to atmospheric influences. In some instances—Clarke's Rock, for example—the cellular, gossany appearance imparted to certain strata by the decomposition of the original organic remains, and the subsequent alteration of the investing salts into powdery oxides, has given rise to an erroneous impression that the "gossan"-like outcrops are caps of metallic lodes.

Evidently these early prospecting operations failed to reveal any workable copper lodes. Later a stamp battery and smelting furnace were established on the opposite side of the river in connection with the lead ores, but apparently were little used; it cannot, however, be said that the prospects of the field have been exhausted.

In 1907, a little prospecting was done in this locality in a gossany outcrop.

Cooma Division.

Berridale District.—Copper ore occurs in G. Rogers' conditional purchase, about 7 miles from Berridale, alongside Jindabyne-road.

In 1906, a shaft was sunk 30 feet on a 1-foot quartz vein, showing a little carbonate of copper; reef thins to 6 inches in sinking and in face of drive east for 34 feet; no sulphides yet visible; picked ore, probably 5 to 7 per cent. copper.

Three and a half chains along the strike, N. 85° W., traces of copper carbonates are exposed in a shallow opening.

One hundred and thirty feet along the south-eastern strike another quartz reef cuts the former on a N. 30° W. strike; this has not been tested.

On J. Constance's portion 40, parish Cootralanta, county Wallace, T. Hooper and party in 1906 sank about 25 feet in granite, with quartz veins or strings irregular and inconstant; specks of copper sulphide and traces of green carbonate are associated with the quartz and occasionally present in the country; no defined channel visible.

Kiandra Division.

Blue Creek Reefs—Bradley's, about half a mile above junction with Yarrangobilly River, parish Yarrangobilly, county Buccleuch.

First opened by H. Bradley in a 12-foot tunnel, and open cut about 20 feet higher.

Strike, N. 60° E.; dip, nearly vertical; thickness, 4 to 5 feet; veinstone quartz with bands and angular fragments of slate, with copper and iron pyrites very sparingly distributed; stains of carbonate in surface stone; occurs in altered slate; elevation about 300 feet above river; no value as a copper lode.

Blue Creek Reef, about half a mile from Yarrangobilly River, below Yarrangobilly Caves Reserve.

Situated about a quarter of a mile up Blue Creek from Bradley's Reef, and about 235 feet higher.

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Several thin quartz reefs exposed in a bluff of altered slate, ranging from 3 inches to 14 inches in thickness.

The quartz veins carry small particles of chalcopyrite, mostly in small vugs; not promising.

Tumut Division.

Bogong Copper Mine, parish Banoo, county Buccleuch, 15 miles east of Tumut.—Inspector Hooke reported (P.B. $^{2}\frac{4}{0}\frac{2}{4}\frac{2}{2}$) copper-bearing formation in serpentine. Aided for 100 feet of sinking.

Further report. Shaft, 80 feet; driven north 25 feet and south 10 feet, at 50-foot level; channel mainly crushed country, with isolated ore bodies; ore—principally bornite, with a little carbonate; about 14 chains north an outcrop occurs, seamed with thin films of bornite.

Thirty tons of ore despatched, averaging 25 per cent. of copper.

Cooma Division.

Bredbo Copper, Silver, and Lead Mine (late Baalgammon), portion 5, parish Bransby, county Beresford, about 4 miles east of Bredbo Railway Station. Private land.

Prospected about 1880. No details available. Country—Limestone, between slate and quartz-felsite. Early workings consisted of a shallow shaft and tunnel, the latter cross-cutting towards, but not reaching, the principal ore body.

Recent developments to March, 1907, deepening shaft to 64 feet, and starting drive on strike south-easterly.

Workings disclose neither walls nor defined ore channel. Ore consists of copper pyrites and galena sparingly distributed in quartz, and of irregular occurrence.

Nature of occurrence well exposed in small drainage channel crossing strike of limestone. Between the quartz-felsite on the west and banded slate and limestone on the east, numerous thin quartz strings carrying galena, and in places copper, occur parallel in a width of about 270 feet of limestone and slates. In the only one of importance—from 1 ft. 6 in. to 2 ft. 6 in. thick—the shaft has been sunk; the others are mostly from $\frac{1}{4}$ to 1 inch thick, the widest being 5 inches.

About 6 chains north-westerly a shallow opening shows quartz, with stains of copper carbonate and a little pyrites, in slate. Here the lode cuts across the bedding of the country. Further along the strike is an old shaft in banded limestone and slate, with carbonate of copper stains and galena, the latter more prominent.

From recent developments in the shaft about 4 tons of dressed ore were obtained, an average sample of which yielded :—

No. 07-3457—Copper	11·07 per cent.	
Gold	a trace (under 2 dwt.)	per ton.
Silver	2 oz. 3 dwt. 13 grs.	,,

A sample of the better grade limestone revealed the following composition on partial analysis :—

No. 07-3455—Calcium carbonate	88·75
Ferric oxide and alumina	1·60
Gangue	8·10
Magnesium carbonate and undetermined	1·55
	100·00

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TUMUT AND ADELONG MINING DISTRICT—*continued.*

Bredbo District.—Reed and party's copper lode about half a mile south of the Bredbo Mine. Portion 179, parish Bransby, county Beresford. Country, crushed quartz-felsite; two quartz reefs carrying copper. Striking N. 10° E. about 15 feet apart. Copper carbonates, and sulphides very leanly distributed through the quartz. One shaft on west reef down 21 feet in April, 1907. Vein from 12 inches to 20 inches thick, dipping easterly at about 65°.

East reef opened for a considerable distance by small cuts; reef 5 to 18 inches thick.

An average sample from the 21 feet shaft yielded :—

No. 07-3456—Copper	.....	3·75 per cent.
Gold	.....	a trace, per ton.
Silver	.....	14 dwt. 3 grs. per ton.

An average from south end of provings on east reef, yielded :—

No. 07-3458—Copper	.....	3·72 per cent.
Gold	.....	a trace per ton.
Silver	.....	17 dwt. 10 grs. per ton.

Tumut Division.

Brungle (Upper).—Inspector Godfrey reported (P.B. $\frac{a\,2\,0\,4}{9\,9}$) an outcrop heavily charged with copper carbonates on P. Kiley's C.P. 112, parish Brungle, county Buccleuch. Aided to sink 50 feet. Results poor.

Queanbeyan Division.

Congwarra, or Cowley Copper Lode, at the junction of the Cotter and Paddy's Rivers, in portion 20, parish Congwarra, county Cowley, about 27 miles from Queanbeyan.—Copper ores occur in this locality in a bed of limestone, in granite country. The limestone has an apparent N.E. and S.W. strike. The deposit on portion 20 has been prospected to a small extent by open cuts and a tunnel. Sulphides associated with a hornblendic rock are exposed in the tunnel, but not in payable proportion. The outcrop shows abundance of iron oxide from alteration of pyrites, and stainings of copper carbonates. This deposit is being further prospected by the Cowley Copper Development Syndicate, Limited.

Other deposits occur higher up Paddy's River. The Under Secretary for Mines in 1895, states that from Coyle's Mine 60 tons of ore were raised, yielding copper to the value of £150 and silver to £105 (Ann. Rept., 1895, p. 61); but it is not certain whether it is identical with the lode under description.

Cooma Division.

Cooma Copper Mine, Middle Flat, portion 25, parish Montague, county Beresford.—Large gossan outcrop in quartz-felsite, stained with carbonates of copper.

Position in 1898.—Shaft 50 feet deep. Traces of carbonates in several places near shaft on west side. Shaft started on about 15 inches of good carbonate ore which, however, gave out at 23 feet, the length of the ore shoot being about the same. Shaft passed into pyritous stone at about 50 feet (the water-level), containing little more than traces of copper.

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Aided for 50 feet of cross-cutting to intersect western outcrops; not availed of.

Inspector Polkinghorne reported subsequently (P.B. $\frac{8}{10}$) that layers of black oxide and sulphide were cut at 67 feet. Probably enriched zone of subsulphide.

At 63 feet a cross-cut extended east 10 feet, apparently to hanging wall. A drive along the wall south 21 feet, and north 12½ feet on a nice vein of copper mineral.

Aided to sink to 200 feet level. At 100 feet porphyry reported with copper, iron, and arsenical pyrites. Water making at rate of 2,500 gallons per hour.

At 129 feet water heavy, and no change in mineral conditions. Apparently end of test, though in 1900 £50 worth of ore was reported to have been raised (Ann. Rept., 1900, page 55).

Apparently western portion of outcrop has not been tested by cross-cut from shaft. At surface the best indications are to the west.

Mr. G. T. Litchfield stated that near Buckley's Crossing, on the right-hand side of the Snowy River, between the junctions of the Boloco and Bobundra Creeks with the River, the granite country is traversed by several large quartz reefs, heavily charged with pyrites and oxide of iron. In several places the reefs are stained with malachite, and good specimens of both malachite and chalcopyrite are obtainable. These reefs strike E. and W., and can be traced for several miles.

About 30 miles further down the river, between the entrances of the Matong and Paupong Creeks, in slate country, a large quartz lode occurs on the right-hand side of the river, carrying fluorspar, baryta, copper pyrites, and malachite, and about 4 dwt. of gold per ton. The outcrop is traceable for about 1 mile on an E. and W. strike. From a leader about 9 inches wide, in the middle of the lode, Mr. Litchfield made several assays, which averaged 11 per cent. of copper, 32 per cent. of lead, and 24 oz. of silver, and 4 dwt. of gold per ton. Within a radius of about 2 miles from this reef several outcrops showing copper ores occur. The country is rugged and little prospected.

Cooma District.—Inspector Milne reported (P.B. $\frac{2}{3}\frac{1}{3}$) copper lode in slate in M.L 33, parish Abercrombie, county Beresford.

Strike N. and S., dip E. channel 2 feet to 4 feet wide, well-defined, carrying in bottom of 54 feet shaft, several small veins of yellow ore from 2 inches to 6 inches thick. Assay value, 16 per cent. copper, and 6 dwt. of gold per ton.

Aided to sink to 154 feet.

Cootralanta, M.C.Ps., parish Gegedzerick, county Wallace, about 6 miles from Berridale, and half a mile from the Cooma–Middling Flat Road.

Quartz vein in granite. Strike, N.W. vertical; width at N.W. end of 100 feet level, 3 ft. 6 in. wide; 2 ft. 2 in. at south-east.

Well-defined joint with clay dig on north-east side. Lodestuff-quartz with yellow sulphide; and subsulphide from enrichment; not solid, occurs in patches, strings, and disseminated particles in channel filling. Firsts probably equal 12 to 20 per cent.; seconds 5 per cent. copper.

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Walls appear true, with dig; quartz filling channel mostly, though crushed granite makes in it in places.

Outcrop, ferruginous gossany quartz with carbonates—not traceable for any distance beyond immediate provings.

Lode has been stoped up about 10-feet above the 100-feet level between the main and travelling-way shafts.

The two shafts on the lode 106 feet and 118 feet deep, were cleaned out in 1906, and two parcels of ore despatched, 1 ton from surface yielding 6 per cent.; 9 tons from level 7¾ per cent.

The total output from October, 1906 to 19th September, 1907, during the latest operations, amounted to 76 tons 19 cwt. 3 qrs., averaging 11·39 per cent. of copper at Customs Smelting Works.

Kiandra Division.

Coronation Mine, Lobb's Hole, Yarrangobilly River, M.L. 18, 40 acres, parishes Pinbeyan and Selwyn, county Buccleuch.

Strike N.W. vertical, in Silurian sedimentaries, on north-western continuation of Lobb's Hole Central lode. Channel well defined. Opened by short tunnel and shaft. In shaft 3 in. to 4 in. of rich yellow copper ore showing at 20 feet level, in a channel about 3 ft. 6 in. wide. A former Kiandra syndicate extracted and despatched about 7 tons of ore in 1903. This parcel was taken from a shoot exposed in the river bed. The present shaft is on the river bank; the tunnel starts in a bluff face about 10 feet from the shaft.

Delegate Division.

Corrowong Copper Mine, situated on Corrowong Station, at the east end of Black Jack Range, parish Currowong, county Wellesley.—This mine was discovered about 1880, and subsequently opened by H. T. Allen, of Delegate, to a depth of 30 feet. The ore-vein was reported to have had a thickness of 1 foot at surface. At 30 feet it consisted chiefly of clay, with grains of native copper. Two tons of ore despatched at the time to Sydney are reported to have yielded 10 per cent. of copper and a little gold. During 1898 the Writer visited the locality; operations for reopening had just begun on behalf of Victorian investors. Traces of copper occur over some little distance in granite; but no evidence of a defined ore-body was revealed in the shallow openings so far excavated.

Reopened and prospected by J. Jackson in 1907.

Queanbeyan Division.

Cowley Copper Lode (see *Congwarra*).—Copper ores occur in this locality near the junction of limestone and granite. The limestone has an apparent north-east and south-west strike. The deposit on portion 20 has been prospected to a small extent by open cuts and a tunnel. The outcrop shows abundance of iron oxide and stainings of copper carbonates.

Mr. J. B. Jaquet describes the iron ore as essentially magnetite, with varying amounts of hornblende, and the greater portion of it as of excellent quality. The estimated quantity in sight being at least 1,000,000 tons.[1]

[1] Memoirs Geol. Surv. N. S. Wales, No. 2, 1901, p. 60.

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Inspector D. Milne reported a strong ironstone blow was being prospected in this lode in 1907, in which a bunch of copper ore was showing; but the results did not prove satisfactory. (Ann. Rept., 1907, p. 81.)

Now being tested by the Cowley Development Syndicate.

Gundagai Division.

Darbalara.—Portion 58, parish Darbalara, county Buccleuch.

Inspector H. Hooke reported (P.B. $\frac{8}{0}\frac{1}{0}\frac{8}{0}$) a quartz vein in serpentinous schist, carrying copper carbonates, stainings of which are common in the rocks of the vicinity.

Aided to sink 35-feet shaft to 100 feet. At 64 feet a large formation reported consisting of schist, quartz, and pyrites; but no further record is available.

Darbalara Copper Lode, in T.S. Reserve No. 18,220, parish Darbalara, county Buccleuch.

Outcrop discovered in serpentine. Grey sulphide from vein 1 ft. 6 in. wide, yielded :—

No. 08-2176—Copper, 16·32 per cent.
Gold, a trace.
Silver, 1 oz. 10 dwt. 11 grs. } per ton.

Carbonates from vein 5 inches to 6 inches wide, yielded :—

No. 08-2177—Copper, 33·85 per cent.
Gold, a trace
Silver, 2 oz. 16 dwt. 15 grs. } per ton.

Cooma Division.

Dartmoor Copper Mine, portion 135, parish Bunyan, county Beresford, about 4 miles south-easterly from Cooma Railway Station.—The main lode occurs at the junction of felsite and Silurian slates, with limestone in close proximity. The ore occurs in the soft rotten slate at the junction.

The mine was originally opened in 1888. In 1897 attention was again given to it, a shaft being sunk 54 feet, crosscut at bottom 20 feet, driven and stoped 30 feet from 23-foot level to surface. The average thickness of lode-stuff from which the ore was picked was about 4 ft. 6 in. Strike, north and south; dip, west at 56 degrees.

In the shaft a cross-course about 8 inches thick was encountered.

During the above operations about 36 tons of ore were sent to smelting works, with the following returns :—

	tons	cwt.	qrs.	lb.	Smelting Works.	Yield.	Value. £ s. d.
Jan., 1897 ...	10	0	0	0	Wallaroo	Copper, 10 per cent. ..... Silver, 36 oz. per ton.....	91 18 3
Aug., 1897 ...	6	6	3	11	Smelting Co. of Australia.	Copper, 14·70 per cent ... Silver, 49 oz. per ton.....	76 6 9
Oct., 1897 ...	5	0	2	2	do ...	Copper, 16·9 per cent. ... Silver, 36oz. 13dwt. 19grs. per ton	61 11 6
Dec., 1897 ...	6	6	1	14	do ...	Copper, 11·5 per cent..... Silver, 19 oz. 1 dwt. 16 grs. per ton	48 18 11
Feb., 1898 ...	6	0	0	0			
							£278 15 5

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Aid was subsequently granted to sink to 100 feet and crosscut. At 64 feet water became very heavy, a whip being erected to cope with it.

In 1905 the mine was again taken up after being idle for some years.

The Dartmoor East Block Proprietary were prospecting the "East Lode," close to the main lode. It occurs in quartz porphyry close to the junction with limestone, and strikes north 50 degrees west. The outcrop is largely quartz, and of considerable width. At the south end of the main outcrop about 4 feet of lodestuff had been exposed in a shallow opening, from which assays have yielded up to 10 per cent. copper and 12 per cent. lead. The shaft was being sunk under aid from the Prospecting Vote; at 64 feet heavy water was encountered, necessitating erection of horse-power haulage. Shaft passed through ironstone with copper veins mixed with limestone.

Fiery Creek Gold and Copper Mine, portion 4, parish Rose Valley, county Beresford, 10 miles easterly from Umeralla Railway Station.—Worked on a small scale for many years for gold, copper in payable proportion being discovered by J. Murray in 1906. Lode strikes about north and south and dips easterly in slates and sandstones. Thickness 1 to 2 feet; outcrop about 8 chains; ores, sulphide and black ore; pitch, south; deepest level, about 40 feet; length about 100 feet; output to 20 April, 1907, 26 tons 16 cwt., yielding about £12 per ton.

Kiandra Division.

Gaslight Copper Mine, Tumut River, 1 mile below junction of Yarrangobilly River, parish Pinbeyan, county Buccleuch.—Outcrop in east bank of Tumut River discovered by Chris. Hetherington in April, 1906. Strike, N. 10° W.; dip, E. 10° at N. 55°.

Opened by tunnel in oxidized and partially leached ore. Channel about 2 feet to 4 feet wide, pinches and makes occasionally. Shaft, started close to river bank, down 10 feet, but water prevented inspection. Some rich yellow sulphide raised, partially oxidized into oxide, or more probably an enriched subsulphide (chalcocite), assaying up to 32 per cent. in picked samples. About 5 tons of dressed ore ready for despatch, a roughly extemporised jig being used in concentrating it, the ore being granular and loose.

About 200 feet of backs would be obtainable by extending tunnel just above river level; but at the present end (70 feet) the lode pinched and driving ceased. Doubtless it would make again if followed.

The ore in the shaft is reported as 14 inches wide at one end. In the tunnel it varied from a streak to 10 inches.

Latest recorded developments (*6th January*, 1908).—Shaft sunk to 24 feet, when water overcame the local appliances. About 100 tons of ore at grass.

A shaft 60 feet deep was sunk on the opposite bank of the river on the strike of the lode; channel of lode located, but only slight traces of carbonates in the dig.

Cooma Division.

Gegedzerick Copper Lode, in G. Rogers' conditional lease, portion 54, parish Cootralanta, county Wallace, 17 miles west of Cooma.—Opened by shafts and shallow openings about 1872. Reopened in 1907 by Lowe and party. Old shaft cleaned out and slightly deepened.

The lode strikes N. 60° W. in granite, vertical. Lodestuff consists of quartz and rotten granite; true width not disclosed, as the rotten country has been to a certain extent saturated from a joint with deposition of a little

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copper carbonate. At bottom the joint is filled with black stains probably of subsulphide of copper. Native copper grains are obtained by washing the latter.

The average sulphide ore at grass probably runs about 5 to 6 per cent. of copper. A picked sample assayed :—

No. 07-2090—Copper	.....	13·95 per cent.
Gold	.....	7 dwt. 15 grs. per ton.
Silver	.....	11 dwt. 23 grs. ,,

Gundagai, Adelong, and Tumut Divisions.

Gundagai-Tumut District.—In the vicinity of Gundagai, Adelong, and Tumut copper ores occur in numerous places, but in one only—Snowball Mine—in sufficient quantity to work. The following localities have been noted:—

Snowball.

Red Hill, 7 and 12 miles from Gundagai, ores assaying 6 to 11 per cent.

Mount Parnassus, Gundagai, assaying up to 11·61 per cent.

Parish Wagara, assaying 6·42 per cent.

Darbalara, in serpentine on the south side of Mount Lightning, indications cut out at a shallow depth.

Wyangle, in serpentine on Geary's property, assaying 26·60 per cent.

Brungle.

Adjungbilly Creek, in Tea-tree Gully, ¾ of a mile south of Adjungbilly Creek.

Mingary Mount, about 3 miles S.E. of Snowball Copper Mine.

Gundagai Mine, 7 miles from Gundagai, portion 205, parish Kimo, county Wynyard.

Queanbeyan Division.

Hall, parish Gininderra, county Murray, 24 miles south-east of Yass.—Warden Maitland stated that 10 tons of ore from this locality, treated in Sydney, yielded 14 per cent. of copper and 8 dwt. of gold per ton.

Cooma Division.

Jindabyne Copper Mine, portion 94, parish Jinderboine, county Wallace: about 4 miles from Jindabyne, and about 1 mile from the Cooma-road.

Mr. Andrew Sturgeon, of Jindabyne, stated that the principal work at this mine began about 1884, and that operations ceased about 1889, when many mines in the Colony were closed owing to the great fall in the value of copper. The shaft had reached a depth of about 80 feet.

Under a provisional agreement with the owner, Messrs. Skidmore and Molesworth obtained from 3 to 22 per cent. of copper and 16 dwt. of gold per ton by assay from the accessible portions of the lode (the shaft having caved in), and from a large outcrop about ¼ mile to the south.

Examined by the Writer in 1907.

Quartz vein in granite. Strike, N. 80° E.; dip, S. 10° E. Traceable for a considerable distance westerly. Proved by several shafts and shallow openings for a length of about 175 feet; and in one shaft to a depth of 80 feet. Copper stains are again visible about 9 chains west of 80 feet shaft, where a little gossanous quartz occurs.

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TUMUT AND ADELONG MINING DISTRICT—*continued.*

In the 80 feet and other shafts, copper carbonates occur as films on joint faces of quartz. At 80 feet slight traces of sulphides are visible.

No ore dispatched. Appearances unfavourable for solid or permanent makes of ore.

Tumut Division.

Kangaroo Mount.—Copper ore was discovered by J. A. Harrison, about 1 mile from Mr. Owen's homestead, near the Mount. The apparent width of lode was reported as 6 feet at surface, in serpentine, carrying carbonates and sulphide, but only shallow prospecting by open-cut was attempted.

Kiandra Division.

Kiandra District (see Lobb's Hole Mines).—At the 15-Mile, Tumut River, Geological-Surveyor Young, in 1880, p. 258, recorded the occurrence of small veins of copper pyrites in the slates of this neighbourhood, similar to those at Lobb's Hole, but smaller.

Cooma Division.

Kyloe Copper Mine, M.Ps. 1 and 2, and P.M.Ls. 1 and 2, parish Seymour, county Wallace, 2 miles from Adaminaby, on F. Reynolds' land, 30 miles from Cooma Railway Station.

Discovered by the owner of the land in 1860; taken up as an M.C.P.; opened to 75 feet; no ore sent away.

Held by Messrs. Litchfield and Hassall for a few months in 1901. 30 tons extracted from the 50-foot level are reported to have yielded 16 to 24 per cent. of copper.

Schaefer Brothers obtained possession in 1904, and up to the Kyloe Company's option in the beginning of 1907, despatched about 500 tons of dressed ore to Waratah, for a return of 11 to 25·5 per cent. of copper, and stacked about 500 tons of seconds, worth about 5 per cent.

Aided in 1906 from the Prospecting Vote (P.B. $\frac{1}{0}\frac{9}{8}\frac{0}{0}\frac{1}{1}$) to sink from 75 feet to 175 feet.

The lode strikes N.W. and dips S.E. about 1 in 16 in upper levels, but becomes vertical at 130 feet; occurs at or near junction of granite and slate.

Proved by shafts and levels for a length of about 550 feet, and for depths ranging from 65 to 130 feet (to April, 1907).

The lode occurs in quartz-felsite (which passes into highly quartzose aplitic, and biotitic granite away from the channel); very close to junction with slate; in fact, at the 130-foot level, south-east end, slate forms one wall.

The lode varies in thickness from 2 ft. 6 in. to 5 or 6 feet where bunches occur. In the early workings only the better grades were mined, leaving a skin on walls. In the centre of the ore channel a later fissure occurs, particularly noticeable from 70 feet downwards. Where solid chalcopyrite forms its walls they have been slickensided and burnished. The ore impregnates the quartz-felsite of the channel on both sides of the central fissure, the purest usually occurring in close proximity to the crack. The greatest width of high grade ore so far encountered being about 3 feet.

The ores consist of quartz with carbonates, cuprite, and bornite in the oxidized zone. A little powdery chalcocite occurs with chalcopyrite in zone of enrichment about the 40-foot level. Below this, yellow sulphide occurs, and when free from gangue is of very pure quality.

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TUMUT AND ADELONG MINING DISTRICT—*continued*.

In places the ore is mixed in small veins and strings through the quartz, and crushed brecciated felsitic channel filling.

Sales of ore to March, 1907, amounted to 269½ tons, yielding from 9 to 24 per cent.

Progress of Development.—A concentrating mill, erected in July, 1907, consisting of a Krupp Ball Mill, and a four compartment May Brothers jig.

The Kyloe Copper Mines (No Liability) supplied the latest particulars to date, May 29th, 1908, viz., greatest depth of proving, 200 feet; length, 350 feet (at 100-foot level).

Concentrates despatched, 266¼ tons; matte produced at mine, 64 tons—50 per cent. grade.

Capacity of concentrating mill, 30 tons per day; capacity of furnace, 10 tons per day.

Kiandra Division.

Lobb's Hole Copper Mine.—On Yarrangobilly River, about 4 miles above its junction with the Tumut River, and about 12 miles from Kiandra. The Rev. W. B. Clarke, in his "Southern Gold-fields," page 108, states that on the "western flanks of the Munniong [Snowy.—J.E.C.] Range, and in the mountainous regions of Jagungal or Big Bogong and Kiandra, ores of copper abound, sulphurets and carbonates of that metal promising a profitable field of labour and enterprise. Such have been long known to exist in the great breaks of the Tumut, near Lobb's Hole."

Mining probably began at Lobb's Hole about 1874, for in that year the following parcels of ore from the deposit were treated at Waratah:—

5 tons	16 cwt.	; yield,	26¼	per cent.	of	copper.
8 ,,	10 ,,	,,	26½	,,		,,
2 ,,	10 ,,	,,	26½	,,		,,

In 1892, aid was granted to Weselman and party to continue sinking on this lode to 160 feet, but they abandoned it after the 80-feet level was reached. Afterwards, the pumping plant was removed to Storey's Reef, Paddy's River, near Tumbarumba. Later, some members of the party re-pegged the ground, and, subsequently, it was examined by E. C. Whittell, who reported the lode to be 3 inches, with occasional bunches 12 inches thick, as proved by several shafts for about 1,130 feet horizontal and 30 to 40 feet in depth.

In 1901, Geological Surveyor Andrews reported the Lobb's Hole lode as occurring " in the bed and alongside the Yarrangobilly River, the latter lying in a gorge exceeding 3,000 feet in depth; the country consisting of quartzite breccias, and silicious argillaceous strata, overlain by conglomerates, sandstone, quartzite, limestones, and slates of the same age. Folding by great granite intrusions is very pronounced; the strata at the mines being forced into a dome-shaped mass, possessing an almost horizontal dip, but inclined in all directions from this spot as a centre "

The Lobb's Hole lode had then been traced for a considerable distance along the river bank. It varies from 4 to 18 inches in width, averaging about 7 inches of rich yellow ore. Rarely lenticular patches of ore occurred as much as 3 feet in width. In other parts, the walls closed almost to the exclusion of ore.

Pumping and haulage was by water power obtained by means of a race. Ore packed on horseback to an elevation of 2,400 feet above the river; thence by teams to Tumut.

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E. C. A ndrews. **Yarrangobilly Valley. Lobb's Hole.**

E. C. Andrews. **Lobbs' Hole Copper Mine, Yarrangobilly River.**

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TUMUT AND ADELONG MINING DISTRICT—*continued.*

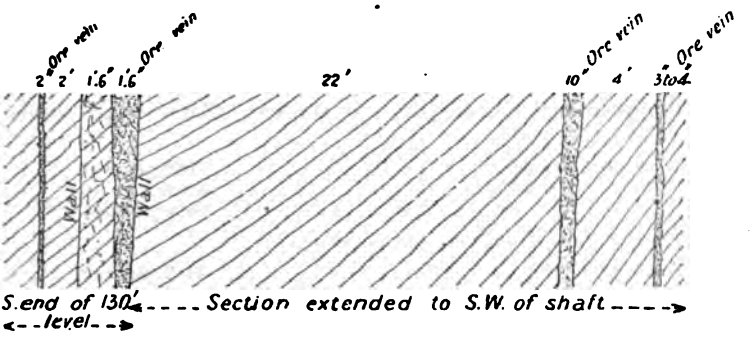
The main shaft was deepened to 130 feet in 1902.

In 1906 the workings were flooded, necessitating more powerful pumping plant.

In May, 1907, the prospectus of the Lobb's Hole Copper Mining Company, N.L. was issued, and the company subsequently floated for the purpose of securing Messrs. Adolph R. Reeckmann and Julius Fostrom's interests in M.Ls. 1. 30, and 31, parishes of Pingany and Selwyn, county Buccleuch, which cover the Lobb's Hole lode.

At this period the ore-lens had been proved for a length of 540 feet out of 790 feet along its strike, N. 65° W.; and to a depth of 130 feet. The flow of water averaged between 4,000 and 5,000 gallons per hour.

In April, 1907, the Writer visited Lobb's Hole and measured the following section at the south-east end of level at 130 feet. In a crosscut south-westerly from the shaft at this level two other parallel veins of ore were cut—these are included in the section :—



In the south-eastern level, at 130 feet, a solid mass or ore 6 feet wide was encountered at 200 feet from the shaft, consisting of 2 feet of rich yellow ore, and 4 feet of mixed iron and copper pyrites. The clean ore was equal to 28 per cent. copper; the mixed sulphides gave the following excellent smelting mixture :—

No. 07-3085—Copper	6·10	per cent.
Iron	39·90	,,
Silica	13·28	,,
Gold	1 dwt. 2 grs.	per ton.
Silver	9 ,, 19 ,,	,,

The widest bunch of clean ore yet discovered in the lode, according to Mr. Reeckmann, was 4 feet, the average thickness being about 7 inches. The thicker bunches make where rolls occur, and the dip flattens. As the underlay steepens, the ore pinches.

In the ore-vein itself a later fissure occurs, through which water percolates so freely as to wear the chalcopyrite surfaces smooth like an ordinary water-worn surface.

This percolation is evidence of extensive fissuring, for the water rises under pressure from below, gas being evolved. This gas is slightly inflammable when allowed to accumulate in old workings. It causes considerable movement—like ebullition—when water is allowed to accumulate at the point of escape. An attempt was made to obtain a sample for analysis, but the bottles

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leaked in transit. The mine water yielded the following results:—(05–360) Total solids (dried at 220° F.) = 118·160 grains per gallon. The solids consist of chloride of sodium, calcium carbonate, and a little magnesium carbonate. No sulphuretted hydrogen or sulphur detected.

The channel of the Lobb's Hole lode is very true and persistent, but only partly occupied by copper ore, the balance being country more or less crushed. Blanks occur, particularly on the north-western strike, where metal values are practically or wholly absent.

On the south-eastern strike a long blank also occurs, but good ore made again 300 to 400 feet from the shaft.

The ore usually makes solid and of unusual purity. The average value of 1,833 tons extracted prior to sale of the mine to the present company on 1st April, 1907, was a shade over 28 per cent. of copper. Rarely did the consignments vary 1 per cent.

During Messrs. Reeckmann and Fostrom's mining operations, pumping and haulage was by means of a race working a Pelton wheel under 50 feet pressure. The ore was hand-picked, and the solid selected ore broken to convenient gauge and bagged. The remainder was broken and jigged by hand, in two jigs of 4-holes to the square inch. The fines afterwards passed into an 8-hole jig.

The tailings from the 4-hole jigs were stacked. An average sample of the latter gave—

No. 05–3083—Copper	6·82 per cent.	
Gold	a trace	per ton.
Silver	6 dwt. 13 grs.	

The slimes or fines from the jigs yielded :—

No. 05–3084—Copper	11·55 per cent.	
Iron	14·70 ,,	
Silica	47·02 ,,	
Gold	a trace	per ton.
Silver	7 dwt. 4 grs.	

From the 4-hole jigs the most pyritic ore is picked out and dumped. An average sample gave—

No. 05–3082—Copper	8·25 per cent.	
Gold	2 dwt. 4 grs.	per ton.
Silver	8 ,, 17 ,,	

These all await treatment when the local smelting plant is erected, the paddocks in hand will average from 7 to 10 per cent of copper.

In the first half-yearly report of the company, 30th June, 1907, it is stated that the 130 feet level had been continued south-easterly 57 feet, making the total length in that direction from the shaft 345 feet. Six inches of 28 per cent. ore continued in the drive for the first 40 feet; but in the last seventeen pinched to 2 or 3 inches.

The advantage of the site is permanent and cheap motive power from the continuously flowing Yarrangobilly River, for all mining purposes, including milling, lighting, &c., which offsets the disadvantages of transport, particularly now the latter have been lessened by the completion of the new road out of the gorge, which enables teams to reach the mine.

The previous costs of transport amounted to £2 15s. per ton by pack-horses and teams to the Tumut railway station; thence 15s. 3d. per ton for railway freight to smelting works. Total, £3 10s. 3d. per ton.

The purity of the copper ensured a smelting allowance of 50 shillings per ton of copper.

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The second half-yearly report for half-year ending 31st December, 1907, gives the following particulars of works in progress:—

Water-race 2 miles long completed, capable of carrying a flow of water 7 feet wide by 1 foot deep.

Substantial dam constructed across river at intake; 30-horse-power turbine placed in position near shaft, and connection made with outlet of race by heavy wrought-iron pipes, 33 inches in diameter; heavy Cornish lift pump, with 8-inch columns placed in position in new shaft.

Poppet heads erected. An attempt to deepen shaft with original prospectors' appliances failed; unable to cope with water. The rapidly increasing flow of water in the shaft below the 130-foot level is attributed to a 6-inch vein of high grade ore cut at 147 feet. Another vein (5-inch) was intersected higher up when timbering.

A reverberatory furnace is being erected to smelt ore after clamp roasting; by blending firsts and seconds it is expected a 12 per cent. grade can be maintained. Red bricks being made at mine.

Lobb's Hole (additional sites).—R. Joyce took up a 20-acre lease in parish Yarrangobilly, county Buccleuch, to north-east of Lobb's Hole, in 1903. Drove 25 feet in a copper vein about 1 inch thick of pure yellow sulphide.

Forty acres taken up by Fostrom and party in 1907, adjoining Lobb's Hole Proprietary on the south; and south of this again an 80-acre block by Brown and McGregor. Copper stains are visible, but no prospecting had been done.

About 5 miles above Lobb's Hole, Smith and Thomas opened a copper vein in the bank of the river; and sank 14 feet in a formation about 2 feet wide, containing about 1 foot of mixed quartz and copper ore.

Lobb's Hole Central Mine (formerly Alpine, and later Sonoma), MLs. 19 and 32, parishes Pinbeyan and Selwyn, counties Buccleuch and Selwyn.—Adjoining Lobb's Hole Proprietary Mine. Two parallel lines of lode occur in this mine, both traversing the river bed until it bends away from the strike.

The original prospecting shaft (Kerry and Forrester's) is on the south bank of the Yarrangobilly. In 1901 Geological Surveyor Andrews described this line of lode (the Alpine) as well pronounced, containing ore equal to the Proprietary, but narrower, from 3 to 4 inches thick, outcropping for the greater part of its length in the river bed. Dip, south. Appears to junction with the main vein about 7 chains east of Lobb's Hole Main River Shaft. A shaft was sunk south of outcrop to cut reef at a depth and then to drive under river. This shaft was carried down about 70 feet; 10 tons of ore raised from it realised 32¼ per cent. of copper.

In 1904 the shaft was unwatered; apparently little done.

In 1906 the workings were flooded; but unwatered at end of year.

In May, 1907, the leases were floated into the Lobb's Hole Central Company. At this time two shafts had been sunk on the north bank on a parallel vein to the Alpine, to depths of 28 and 38 feet, at a distance of 40 feet apart, and but a few feet from the water's edge. Both north-west and south-west along the strike from the shaft the vein ran into the river bed, as per sketch plan.

The lode channel exposed in the shafts is well defined between true walls about 4 feet apart. The character of the filling is illustrated in the accompanying section of the lower part of the 38-foot shaft. Here about 8 inches of rich yellow sulphide is separated by 3 to 4 inches of slate; the rest of the channel is also filled with slate.

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TUMUT AND ADELONG MINING DISTRICT—*continued.*

Pumping was performed by water-power, a small water-wheel being set in the river itself, and worked by the current.

Since the company took over the property a new (main) shaft has been started well out of flood reach, and it is intended to cross-cut to the lode at a depth so as to leave a solid cover, for the lode traverses the river bed for the greater part of its course.

During the previous operations, about 50 tons of high-grade ore have been despatched.

In subsequently cross-cutting from the main shaft to the lode, three veins were cut from 2½ inches to 10 inches thick of rich yellow sulphide.

Tumut Division.

McAlpine Copper Mine, portion 30, parish Wagra, county Buccleuch, about 20 miles from Tumut, and 19 from Gundagai.—This lode was originally opened to a depth of 90 feet at junction of granite and serpentine. Reopened by J. J. Kelly about 1898, who sank another 20 feet, and took out 38 tons of ore; 9 tons 17 cwt. of which yielded 10 per cent. of copper at Dapto. A sample recently taken by J. M. Dodds from a 6 feet lode, cut in east drive, from 104 feet level, yielded:—Copper, 13·74; zinc, 18·73; iron, 18·62; sulphur, 22·48; silica, 8·15 per cent.; gold, a trace; and silver, 3 dwt. 6 grs. per ton.

About one mile north, Inspector J. James reported (P.B. $\frac{21}{0}\frac{9}{8}\frac{21}{}$) a copper vein, about 3 inches thick, in granite and slate; strike N. and S. Aided to sink 60 feet. Cut out at 30 feet. Three tons of ore raised returned 6 per cent. No improvement at 40 feet.

Cooma Division.

Macanally Gold and Copper Mine, portion 3, parish Rose Valley, county Beresford.—Worked for many years for gold. Copper discovered by J. T. Ireland in 1906. Strike about N. and S., dip. E. Ore shoot pitches north. Depth of proving, 70 feet. Thickness of vein, from a few inches to 1 foot. Length of proving, about 200 feet. Outcrop, about 500 feet.

The following particulars of output were supplied by Mr. J. Murray:—

4 tons yielded £84 15s. 3d. for gold and copper.

	Gold per ton.
22nd October, 1907, 21 tons 11 cwt. yielded 9·18 per cent of copper	2·158 oz.
8th February, 1908, 10 tons 12 cwt. yielded 12·07 per cent. of copper ...	1·59 oz.
8th April, 1908, 8 tons 10 cwt. assayed 2·49 per cent. of copper...	3 oz. 8 dwt. 9 grs.

8 tons 12 cwt. yielded 3·84 per cent. copper, 3·127 oz. gold.

Depreciation in copper value in the later parcels being doubtless due to passing below the zone of enrichment.

Gundagai Division.

Mingary Copper Lode.—Under Mingary Mount, about 14 miles south of Gundagai, and 3 miles north of Snowball Mine. Lode reported, 6 inches to 6 feet wide. Limestone in close proximity of the latter.

Cooma Division.

Monaro Copper Mine, late Dyball's, portion 92, parish Arable, county Wallace; about 11 miles from Berridale.—Opened about 1898 by H. Dyball. Later a syndicate sank to about 39 feet and extracted 3 tons of ore.

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The present Montreal Syndicate entered into possession, under authority to enter, in February, 1907. Cleaned out old shaft and started a new one at south-west end of workings, making four shafts in a distance of 40 feet in direction N. 65° E. The new shaft, by March, 1908, had been sunk to 100 feet, where a little iron pyrites was exposed. Aided to drive from the bottom under the old surface workings to test persistence of lens in depth.

In the old shaft, cleaned out by the Montreal Syndicate, a considerable chamber had been excavated, and a short drive put in to the north.

The country is soft, slippy-headed slate, with sandstone bands, in which copper carbonate stains are visible for a width of 20 feet or more, without defined walls or definite channel. Small concretionary nodules of rich grey ore, and carbonates as veins and impregnations occur at intervals, and search for these has caused the "rooting" visible in close holes. If no defined ore body be encountered in the drive at 100 foot level, the prospects of further developments will be hopeless.

A sample of the concretionary grey ore yielded 34·30 per cent. of copper on assay ($\frac{A}{S}\frac{S}{T}$), a trace of gold, and 2 oz. 7 dwt. 22 grs. of silver per ton. About 25 chains north-west, in same lease, a 6-inch vein of quartz, containing a little galena and yellow ore, occurs in granite. From an opening in it about 8 feet deep, a picked sample gave 15·35 per cent. of copper, and 20 oz. of silver per ton. The average, however, would be very low. Too small to merit attention.

Monmouth Copper Mine, Gulgandra Creek, Monaro.—In the catalogue of the Sydney Exhibition of 1870, copper ores from this mine are mentioned. Work was at that time being carried on by a party of Victorians, who were sinking a shaft.

Queanbeyan Division.

Mount Bullen.—About one mile S.E. of Coyle's Mine. Mr. Danvers Power, stated, in 1898, that a recent discovery of copper ore was made at Mount Bullen in an amphibolite dyke in felsite and syenite country. The dyke has a width of about 1 chain and can be traced over Mount Bullen to the Cotter River, where copper stains are visible. The outcrop consists generally of magnetic iron with stains of copper carbonates. The only proving is to a depth of about 10 feet by a length of 10 feet in copper-stained lodestuff.

Mr. Power contributed the following notes of position in March, 1900:—"Tunnel, 98 feet; winze, 36 feet from mouth; down 34 feet on underlay. Bottom of winze below level of Paddy's River, about 25 feet below the tunnel level.

"Copper ore occurs in spots and small cracks with magnetite in an amphibolite dyke. No sign of defined lode. Nothing payable disclosed." (Probably refers to Congwarra and Cowley sites.)

Gundagai Division.

Mount Mingary Copper Lodes, Mount Horeb Estate, portion 249, parish Calafat, county Wynyard.—About 2½ miles east from Mount Horeb Railway Station, and 1½ from Calafat.

The principal lode was opened about 1905 for gold. It strikes about N. 5° W., and dips west at about 58°. It has been dissected by a creek to a depth of between 300 and 400 feet. At the creek level a shaft was sunk 40 feet, exposing about 2 feet of quartz veinstone, with a little yellow sulphide of copper and pyrites. It has also been exposed in an open trench

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alongside. A quantity of this stone was stacked for crushing, but a trial parcel of 6 tons only was treated for a reported yield of 7 per cent. copper, and about ½ oz. of gold per ton.

Assays made in the departmental laboratory returned 5 to 7 dwt. of gold per ton.

Copper stains are reported to occur in the outcrop on ridge north of creek.

The lode occurs at junction of slate and intrusive quartz-felsite, and varies from 10 inches to 2 feet in thickness.

Rich specimens of cuprite were found about 100 feet above the shaft on the southern strike. Higher up this ridge sulphides were showing in a 25 feet shaft.

Though not workable as a copper proposition, if gold-bearing to the extent mentioned—5 to 7 dwt.—it would form a useful flux in matte roasting, especially if the adjacent Snowball Mine again became the site of smelting operations.

On the opposite side of the southern ridge traversed by the lode, Fuller's 3-acre block divides the Mingary north and south areas. Fuller's two shallow shafts are on western parallel quartz vein. About 5 tons of stone from it are reported to have yielded as high as 19 dwt. of gold per ton.

On the Mingary South the continuation of this vein has been found, and a shaft had just been started at date of inspection in 1907. Quartz, solid and gossany, is here stained with copper carbonates; the enclosing walls to a slight extent also.

On the east of this lode, some chains distant, the old Hawthorn lode was opened when Snowball Copper Mine was working, a shaft being sunk to 75 feet on a north and south vein, having a thickness from 9 to 24 inches, much resembling the West Mingary lode, but of slightly better grade. A few tons of ore lately raised from it would, perhaps, yield, when dressed, about 7 per cent. of copper.

Within a few chains of the Mingary West lode is an outcrop of limestone, which was burned for lime many years ago to supply requirements of Adelong and Gundagai. This would be useful for Snowball smelting—being only about 2½ miles distant. Its composition is shown in the following analysis:—

	Per ton.
07-3088—Carbonate of calcium	96·89
Ferric oxide and alumina	0·70
Gangue	1·80
Magnesium carbonate and undetermined	0·63
	100·00

Delegate Division.

Mount Trooper.—A little copper ore occurs in granite in the Snowy River Valley, on a low spur opposite Mount Trooper, on the east bank of Sandy Creek, about 2 miles from the Victorian border. Copper ore in minute quantities was also detected by the Writer on the border about half a mile east of the Snowy River. At Sandy Creek a little prospecting was done, but the indications were not favourable for the existence of ore in quantity. A picked sample of the best grade yielded 7·03 per cent. of copper, and silver at the rate of 17 dwt. 9 grs. per ton.

Cooma Division.

Nithholm Copper Mine.—Situated in W. Jardine's Nithholm Estate, 4½ miles easterly from Cooma, and adjoining the Dartmoor Cooper Mine property, parish Montague, county Beresford.

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TUMUT AND ADELONG MINING DISTRICT—*continued.*

The following particulars of bulk tests of ores from this mine were supplied by Mr. J. R. Maccue, Cooma:—

No. 1 sample—7 cwt. 2 qrs., Wallaroo Smelting Works; copper, 29 per cent.; silver, 16 oz. per ton.
No. 2 sample—1 ton 7 cwt. 1 qr., Wallaroo Smelting Works; copper, 8 per cent.; silver, 18 oz. per ton.
No. 3 sample—1 ton 1 cwt. 2 qrs., The Smelting Company of Australia's Works, Dapto; copper, 14·02 per cent.; silver, 7 oz. per ton.
No. 4 sample—1 ton 12 cwt., The Smelting Company of Australia's Works, Dapto; copper, 10·22 per cent.; silver, 21 oz. per ton.
No. 5 sample—2 tons 2 cwt., The Smelting Company of Australia's Works, Dapto; copper, 2·43 per cent.; silver, 5 oz. per ton.

Peak, 9 miles from Cooma.—Mr. J. F. Carey noted a well-defined quartz outcrop traceable for some distance (unprospected), copper carbonates and sulphides showing at two points.

Tumut Division.

Pether's Lode, Jounama Creek, Talbingo.—Strike N. 5° to 10° W. Outcropping in four places—three on north and one on south side of the creek. Best developments at junction of limestone, where garnet has been developed by contact of igneous rock. Copper carbonates and sulphides present. The creek has dissected lode to a depth of about 400 feet below southern outcrop, and 500 below northern. Further north, at a higher elevation, galena is developed to a small extent in limestone. Still further north, about three-quarters of a mile, a massive outcrop of magnetic iron occurs about 1,800 feet above. In the Jounama Creek the outcrop is silicious, with traces only of copper ore. On the first point north of creek, very kindly looking gossan is exposed on west side of limestone, showing traces of copper. Particles of rich yellow sulphide occur in calcite walls of lode—highly altered slate.

North from this point the lode outcrops strong, but very silicious. Specular iron is developed to a small extent at contact in connection with garnet rock.

On the south side the limestone dips east at 32°. Copper stains occur here in small outcrops for about 60 feet, but apparently cannot be traced southerly though not prospected for.

Massive garnet outcrops occur a little higher up Jounama Creek, striking a little west of north.

Queanbeyan Division.

Queanbeyan District.—Copper indications occur in and near the town of Queanbeyan, but nothing payable or permanent has yet been discovered. Copper ores are also reported from near Rose Valley, assaying ($\frac{1}{0}\frac{8}{8}\frac{0}{}$) 9·02 per cent.; from 6 miles from Queanbeyan, assaying ($\frac{4}{0}\frac{7}{7}\frac{0}{}\frac{2}{}$) 13·08 per cent. of copper. From McDonald's Mine, Uriara, 16 miles from Queanbeyan, copper ore, yielding ($\frac{3}{0}\frac{7}{6}$) 6·54 per cent. has been forwarded.

Copper ore is also reported at London Bridge, near Queanbeyan.

In 1906, W. A. Trewenack prospected a deposit in parish Carwoola, 10 tons of ore raised being valued at £90. (Ann. Rept., 1906, p. 48.)

Tumut Division.

Red Hill Copper Mine, portion 30, parish Wagra, county Buccleuch, near Red Hill Homestead.—Inspector E. C. Whittell reported (P. B. $\frac{3}{0}\frac{6}{3}\frac{0}{}\frac{1}{}$) copper and zinc bearing lode at junction of serpentine and granite.

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TUMUT AND ADELONG MINING DISTRICT—*continued.*

Shaft 90 feet. Worked some years before. Payable oxidised ore removed. P. Kiley sold ore to the value of £120. Zinc blende in excess of copper sulphide at bottom of shaft. Bunch of these ores from 1 foot to 6 feet wide.

Aided to sink from 78 feet to 178 feet.

Progress: At 118 feet lode about 4 feet wide, rock hard; a little water making. At 125 feet no copper ore apparent.

Cooma Division.

Rosebank Mine (Hayes, Jennings, and Party's), portion 12, parish of Umeralla, county Beresford.—Held as a 10-acre lease on the Rosebrook Estate. Shaft 40 feet, in slate country. From this mine the following parcels of ore were treated at the Smelting Company of Australia's works, Dapto:—

2 tons, yielding 14 per cent. copper, 11 dwt. of gold, and 2 oz. silver per ton.
2 ,, 10 ,, ,, 9 dwt. 4 grs. of gold, and 2 oz. silver per ton.
1 ton 5 cwt., yielding 16 per cent. lead, 11 dwt. of gold, and 13 oz. of silver per ton.

Gundagai Division.

Snowball Copper Mine, about 9 miles from Gundagai, towards Adelong, Portion 168, parish Willie Ploma, county Wynyard.—Situated on Snowball Hill, at the head of Snowball Creek, a tributary of the Murrumbidgee River.

This lode was discovered by James Clayton, in 1873, close to the marked-tree line on the mountain track between Adelong and Gundagai, and taken up by him as a lease in conjunction with his two brothers. Later, other leases were acquired, and the property passed into the possession of a company.

The earliest official record is that by Chief Inspector Slee, in 1876, to the effect that thirty men were then employed and a furnace was being erected. Gossan outcrop, traceable for about 1,000 feet, but lode only opened for about 100 feet in length. Assays of yellow sulphide reported to yield from 7 to 22 per cent. of copper.

In 1877 a syndicate to properly work the mine was proposed by Mr. S. L. Bensusan. At this time it was reported that the lode in the deepest shaft—100 feet—was 10 feet wide, and consisted of yellow sulphides, averaging about 10 per cent. Other shafts, 45 and 70 feet deep, had the lode from 5 to 9 feet wide, 3 feet of which was reported to be good carbonate ore. Four other shafts had been started on tribute. A tunnel was being driven at right-angles to intersect the lode in the main shaft at the 136-feet level.

In the same year, Mr. Slee reported the deepest shaft as 130 feet, lode 10 feet wide, slaty, with solid bunches of sulphide ore. Two furnaces were in full work, and a third in course of erection. Population, about 150.

In 1878–9 the Warden reported considerable activity at Snowball, and anticipated fair prospects of success when the railway-line to Gundagai was completed.

In 1880 the Mining Registrar reported the abandonment of smelting operations.

In 1881 the property was purchased by Messrs. Benson and Samper, but apparently no work was done, the mineral conditional purchase into which the lease was being converted being cancelled for non-payment of balance due. Later it was taken up as a conditional purchase.

In 1895 and 1896 Mr. Benson partly unwatered the mine and extracted 12 tons of ore from the 175-feet level, and 6 tons from the 100-feet. The two parcels are stated to have averaged 7 per cent. of copper at Lloyd's Smelting Works, Eskbank.

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THE SNOWBALL COPPER MINE

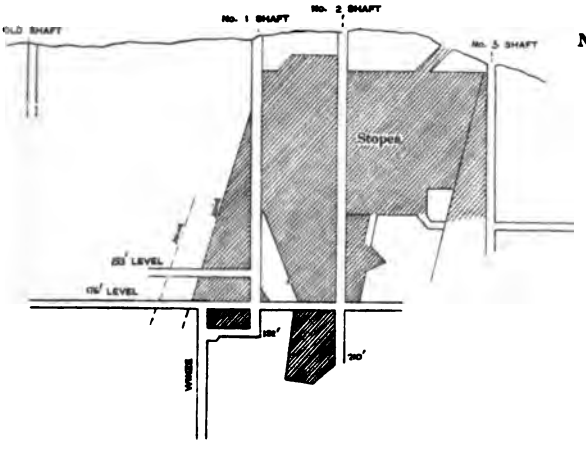
Parish of Willie Ploma. County of Wynyard.

Plan of Workings *(After F. Danvers-Power, Esq.)*

Scale 0 40 80 Feet

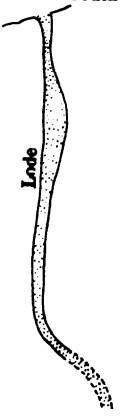
Longitudinal Section

West S.80°E. **East**

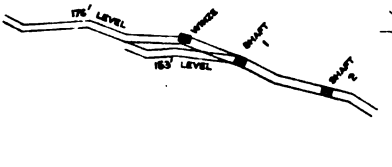


Cross Section

North South



Plan



Plan showing locality

Scale 0 10 20 Chains

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TUMUT AND ADELONG MINING DISTRICT—*continued.*

In 1898 the mine was visited by the Writer. The country consists of slate and igneous rock—partly epidotic—the lode apparently occurring as a junction deposit. The outcrop is a strong one, and extends from some little distance. The workings, however, were confined to about 300 feet in length. The strike is nearly east and west. The old workings were unsafe, and water prevented inspection below 120 feet; but, judging from the old stopes, the ore channel is a wide and strong one, though the ore has evidently been bunchy in places. On one wall slickensides are well developed, which indicates considerable movement, and therefore permanency. At the west end of the workings a joint or cross-course divides the lode; but as ore is seen in the country beyond, there is no apparent faulting. A silicious, gossany outcrop a short distance to the west-north-west is regarded by some as the faulted continuation of the lode; but sufficient work has not been done to test this question. A sample of the gossan ($\frac{2}{0}\frac{2}{0}\frac{2}{0}$) yielded 0·01 per cent. of copper only, which is no guide, as copper is likely to be detected in the country for some distance in this cupriferous locality.

A sample of the rejected ore from the 175 feet level, extracted by Mr. Benson, was assayed ($\frac{2}{0}\frac{2}{0}\frac{2}{0}$) with the following results:—

Copper	1·87 per cent.
Iron	18·49 ,,
Silica	39·00 ,,

Neither gold nor silver.

It is evident that the lower levels of the lode constitute a concentration problem, though bunches may be found of direct smelting ore, as at higher levels.

It has not been possible to ascertain the quantity of copper produced during the smelting operations; but, judging from the slag dump, which roughly measures from 2,000 to 3,000 tons, it must have been fairly considerable, as some of the ores were of high grade.

Mine reopened in November, 1906, by J. M. Dodd; subsequently floated into the Snowball Copper-mining Company, which started operations 18th March, 1907. Unwatered to 150 feet level by June, 1907. Old stopes 4 to 20 feet wide between No. 1 and 2 shafts, 50 feet apart. Ore left on footwall at 80 feet assayed 3 to 4 per cent.

Bottom of No. 1 shaft reached, 6th July, at 192 feet, underhand stope going west of shaft about 35 feet. About 12 feet of ore showing.

Twenty-six tons from west end of lode at 176 feet yielded 6½ per cent. at Blayney Smelting Works.

Samples from this level tried during prospecting operations gave the following returns:—

Assay No.	Description.	Copper, per cent.	Gold, per ton.	Silver, per ton.
			dwt. grs.	dwt. grs.
07-3256	From footwall	3·95	1 2	5 10
07-3257	,, ,,	2·67	trace.	5 10
07-6686	From west drive at 210-foot level	5·27	,,	6 13
07-6687	From old shaft on ridge	8·35	,,	4 8

Revisited by Writer, January, 1908, when the mine was unwatered.

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TUMUT AND ADELONG MINING DISTRICT—*continued.*

Strike of lode, N. 80° W. Dips at first N. 10° E., then nearly vertical, afterwards S. 10° W.; dips at 76° at 100-foot level. Greatest length of proving in old workings about 310 feet. Further westward carbonates have been cut in a recent prospecting shaft—not promising at this point. Channel of old workings up to 20 feet wide, evidencing a strong body of ore extracted to surface from 176 feet. As there are practically no tips the whole must have been smelted as mined, and apparently proved self-fluxing. About 8 chains on eastern strike an old shaft on ridge shows carbonates. The lode becomes irregular at western end of stopes. Indications exist of parallel veins at Snowball. Cross-cutting would be advisable.

The following samples were secured during examination which reveal the character of the ores. Subsequent samples show the nature of the lode in the winze below the 176-foot level, recently unwatered and cleaned out. The latter proved the lode to a total depth of 259 feet from surface. Though narrow (about 2 to 4 feet), the ore in the winze proved of excellent quality :—

Assay No.	Description.	Copper, per cent.	Iron, per cent.	Sulphur per cent.	Silica, per cent.	Gold, per ton.	Silver, per ton.
							dwt. grs.
08-437	Sulphide, S.E. drive 176-foot level from heap at grass.	9·50	22·40	11·64	32·02	A trace	8 17
08-438	Sulphide, west end of lens (bagged ore).	10·57	24·22	13·03	25·80	,,	3 6
08-1036	Sulphide bottom of winze 259-foot level.	16·82	31·78	16·38	13·24	,,	7 15

The prospects obtained in the winze should encourage further test at lower levels, by sinking and driving. It is very probable that lenses of good ore will be found.

The original smelting plant at Snowball consisted of four reducing, and one refining, furnaces. A fairly representative sample of the slag dump yielded the following composition :—

No. 08-606—Silica (SiO_2)	36·70	per cent.
*Alumina (Al_2O_3)	11·96	,,
Ferrous oxide (FeO)	39·97	,,
Titanic oxide (TiO)	absent.	
Manganous oxide (MnO)	·83	per cent.
Zinc oxide (ZnO)	·17	,,
Lead oxide (PbO)	trace	,,
†Copper sulphide (Cu_2S)	·98	,,
Lime (CaO)	1·18	,,
Magnesia (MgO)	8·43	,,
Alkalies and undetermined	1·28	,,
	100·00	

* Including phosphoric acid (P_2O_5) present. † Equal to 0·78 per cent. of copper; silver, 1 dwt. 2 grains portion; gold, a few grains.

Cooma Division.

Snowy River.—Copper carbonates reported to occur about 1 mile below junction of Moonbar and Snowy River, in granite; about 300 or 400 yards back from the Snowy.

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TUMUT AND ADELONG MINING DISTRICT—*continued.*

Gundagai Division.

South Gundagai.—Copper-stained slate occurs in portion 292, parish South Gundagai. Opened by two shallow shafts, but no channels or joints so far disclosed, in which concentration would be likely; copper carbonates staining cleavage of slates.

Tumut Division.

Tumut District.—The occurrence of copper ores at Mingary Mount and in D. Ford's property on the west side of Mingary Range, in parish Califat, and in J. Dean's land on east side of Gilmore Creek, proved the extension of a cupriferous belt between the latter point and the Snowball Copper Mine in parish Willis Ploma, county Wynyard. This narrow belt trends in a N. 37° W. direction for a distance of 9 miles between the points mentioned.

Ford's property is situated at the foot of Mingary Range. The copper belt here consists of crushed porphyry, schist, and serpentine in close conjunction. A thin vein of copper carbonate was opened in the schist and crushed porphyry, but cut out at 23 feet in a shaft sunk in 1899. Judging from appearance, prospects are not good for extensive deposits, though a few tons of good ore are obtainable by careful spalling and picking. A sample of picked ore yielded :—

No. 00-1459—Copper	.....	27·05 per cent.
Silver	.....	1 oz. 3 dwt. 18 grs. per ton.
No gold.		

A short distance S.E. from the shaft, traces of copper carbonates are visible in the porphyry, but are unimportant.

The quartzite outcrops near the porphyry contact are highly silicified, and charged with specular iron ore; simulating lodes in appearance.

The copper indications on J. Dean's property, near junction of Adelong and Upper Gilmore roads, consist of a large untried gossany outcrop, showing slight traces of copper carbonate. It occurs in slates and schists. The iron oxide has evidently resulted from alteration of pyrites. A sample taken from the outcrops showing copper stains yielded :—

No. 00-1458—Silver	.....	5 oz. 8 dwt. 21 grs. per ton.
Gold	.....	nil, per ton.
Copper	.....	a trace.

Three miles from Tumut, on Micalong-road, Inspector E. C. Whittell reported (P.B. $\frac{21}{02}$), a copper-bearing vein in eruptive rock at this site, containing blue and green carbonates, with limonite; thickness, 6 inches; quality good. Aided to sink 50 feet. Ore reported to have pinched out at 10 feet, made again at 18 feet, 9 inches wide; dipping west.

Mingary Mount, parish Calafat, county Wynyard, in Crane's C.P.—Lode 8 to 9 inches thick. Sample from surface assayed (07-345)—Copper, 11·17 per cent.; gold, a trace; silver, 17 dwt. 10 grs. per ton.

From half a mile further north, from a vein 18 inches wide at surface, samples of quartz and slate with copper carbonates yielded :—

No. 07-349—Copper	.....	2·55 per cent.
Gold	.....	2 dwt. 4 grs. per ton.
Silver	.....	13 dwt. 1 gr. ,,

Other samples from this property yielded from 4·10 to 22·39 per cent. of copper.

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TUMUT AND ADELONG MINING DISTRICT—*continued.*

Kiandra Division.

Tumut River.—About 1 mile below the Gaslight Mine, McMillan Bros. sank 30 feet and drove 30 feet in a 5 feet channel, containing mostly iron pyrites, with rare splashes of copper. Formation lying very flat.

About half a mile above O'Heher's Bridge, over Tumut River, copper occurs; only slightly prospected.

Cooma Division.

Wambrook Station.—About 18 miles westerly from Cooma. On this station, about 5 miles north-west of the Gegedzerick Copper Mine, a copper lode was opened about 1878. Mr. G. F. Litchfield stated that it consists of quartz, with malachite and chalcopyrite, striking east and west in granite. The outcrop was not regarded as payable, but some rich specimens were obtained from the lode, which averaged about 3 feet in thickness.

Tumut Division.

Wyangle, parish Wyangle, county Buccleuch.—In Geary's private land copper ores in serpentine have been exposed in an open cut. Assay ($\frac{2}{0}\frac{2}{0}$) yielded 13·64 per cent., and ($\frac{1}{0}\frac{1}{7}\frac{2}{0}$) 20·4 per cent. of copper, and 5 oz. 8 dwt. 21 grs. of silver per ton. A sample from Kiley's 50 feet shaft assayed ($\frac{1}{0}\frac{1}{7}\frac{2}{0}$) 12·30 per cent.

Kiandra Division.

Yarrangobilly, parish Yarrangobilly, county Buccleuch.—One of the well-known Yarrangobilly Limestone Caves bears the name of Copper Mine Cave, because of the proximity of a quartz-reef carrying a little copper ore; in fact, from Yarrangobilly village to the Caves, a distance of about 7 miles, copper ores occur, and numerous small prospecting holes have been sunk, but nothing of importance was proved.

Lower down Yarrangobilly Creek, about 4 miles above its junction with the Tumut River, Lobb's Hole Copper mine is situated.

Inspector J. R. Godfrey reported a large body of porous ironstone 1¼ miles east of 39-mile peg, in village of Yarrangobilly, on Waugh's private land. Strike N. and S. About 300 yards distant shafts had been sunk in limestone on an old lead and copper show. Aided (P.B. $\frac{1}{0}\frac{1}{0}$). Apparently resultless.

Three miles south-west of Yarrangobilly Caves House, Inspector H. Hooke reported (P.B. $\frac{2}{0}\frac{1}{7}$) a well-defined copper-bearing lode apparently in a true fissure, traceable for over a mile. Ore rather poor, but amenable to concentration.

On west side of river, on continuation of Castle Cave lode, copper ore showing at surface, carbonates and possibly grey sulphide.

Batty's shafts, alongside main road, 1½ mile south of Yarrangobilly village. Limestone country. A few tons of carbonate ore sent for trial after concentration by sluice washing. Shafts sunk and abandoned some years ago.

Mount Fiery copper lode, M.L. 4, parish Yarrangobilly, county Buccleuch.—A large bluff of quartz in limestone ending against quartz-felsite. Quartz slightly cavernous and stained with copper carbonates. The quartz occurs irregularly in the limestone.

Further westward, on the same portion, a wide mass of shattered limestone with crystal-lined vugs of quartz, has been superficially tested to about 10 feet deep.

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TUMUT AND ADELONG MINING DISTRICT—*continued.*

In the joints of the limestone stains of copper carbonate occur as a result of oxidation of chalcopyrite, which is discernible in the mass very leanly distributed.

The sinking has been carried out in detrital filling in a cavity in the limestone. Might be advisable to sink about 50 feet and crosscut to ascertain whether copper sulphides make more solid. Aid from Prospecting Vote subsequently granted on Inspector H. Hooke's report, for 100 feet of sinking and 100 feet of cross-cutting.

In mode of occurrence as regards quartz vugs and associated copper sulphides it resembles the Mount Felstead deposit near Cootamundra.

A sample chipped from the exposed faces yielded :—

No. 06-1109	Copper	0·6 per cent.
	Gold	a trace
	Silver	4 dwt. 8 grs. per ton.

A few chains west a shaft was sunk about 1899, on a 2-inch vein of rich copper ore; in an outcrop 12 inches to 15 inches thick, striking N. 65° E. in limestone, and dipping N. 25 W. A few bags of rich ore were raised but not despatched; a sample from them yielded :—

No. 06-1110	Copper	22·03 per cent.
	Gold	2 dwt. 4 grs. per ton
	Silver	13 ,, 21 ,, ,,

The outcrop is traceable between the abovementioned sites by the quartz in the limestone.

About 20 chains west of the west boundary of M.L. 4, between it and Yarrangobilly River, an old shaft and small trenches expose a quartz reef stained with copper carbonates on joint faces and cracks, and containing small cellular spaces after decomposed sulphides.

About 11 chains north of the latter is the deepest shaft on the reserve; sunk in a pipe-like mass of gossan in limestone to a reported depth of 60 feet. Traces of copper carbonate are visible in the gossan, which gives place below to massive cubical iron pyrites with a little copper sulphide. An average sample yielded :—

No. 06-1111	Copper	4·62 per cent.
	Gold	10 dwt. 21 grs. per ton.
	Silver	5 ,, 10 ,, ,,

In M.P. 5, an ironstone outcrop in limestone was opened for silver about 1888, by two shafts. The ironstone has resulted from oxidation of cubical pyrites. Prills of native copper occur sparingly in it; might be useful as a flux if ever smelting is established in the vicinity. This applies also to a large bluff of gossan on the opposite side of gully about 15 chains distant N. 10 W., where old prospecting holes occur.

A sample of the cupriferous iron from the shafts yielded :—

No. 06-1114	Copper	0·55 per cent.
	Gold	a trace.
	Silver	,,

Copper Mine Cave Old Shaft near S.E. corner of M.L. 8.—Two old shafts and an open cut in a quartz vein in limestone. The quartz is partly crystallised and slightly stained with copper carbonates. Thickness, about 5 feet.

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Yarrangobilly Caves Reserve.

Castle Copper Lode., M.P. 1, parish Yarrangobilly, county Buccleuch.—Massive quartz lode; strike, N. 79 E, nearly vertical; thickness about 6 feet; slightly stained with copper carbonates; copper pyrites also sparsely distributed. No work done beyond shallow trenches; not favourable for copper lode. Outcrop traceable towards river, obscured in other direction.

A sample broken from outcrop yielded:—

No. 65-1103—	Copper	0·9 per cent.
	Gold	a trace
	Silver	3 dwt. 6 grs. per ton

Another vein appears to junction with the above on the north side.

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Local Refractory Materials used in the Manufacture of Firebrick.

From consideration of the composition of local refractory materials utilised at various centres (revealed in the following analyses), it would appear that almost any silicious grit or sand with just sufficient clay to bind it, will withstand the melting temperature of copper (2,000° F., or 1,093 Cent. according to Dr. Peters) long enough to serve a useful purpose in smelting furnaces far removed from supplies of the ordinary market firebrick. The composition of some western bricks brings them into a class with pure silica bricks, as the cementing clay is largely silica. In some cases the materials are crushed; in others, they are used in the extemporised pug-mill just as obtained; fragments and pebbles of quartz—as at Girilambone—are frequently as large or even larger, than marbles; none the less, the resulting bricks answer all their requirements sufficiently well to enable the imported article being dispensed with, and thus ensuring a considerable saving in carriage. Cost of transit was a most serious item in the early days of the Cobar copper field. The first firebricks transported from Sydney to Cobar are reported to have cost £50 per thousand. Later they were manufactured locally from a clay brought from Tindarey—about 36 miles northerly from the mine—by the copper teams returning from Bourke for loading. Subsequently a reward was offered for the discovery of suitable clay at a more convenient distance, and a site was selected about 6 miles north-westerly from the mine. This clay, of which an analysis is given, was used in equal parts with crushed quartz and fine-grained sandstone obtained near by. From this mixture firebricks were manufactured, until the use of refractory material ceased on the advent of water-jacketed furnaces in 1893–4.

Fireclays.—Local clays are usually turned to account for manufacture of firebrick, ordinary brick, and mortar or fettling, not because they are the most suitable or satisfactory, but on what Peters terms "the sound business principle of always employing the cheapest material which will fill the requirements of the case." ("Principles of Copper smelting," 1907, page 502.). A principle which naturally applies strongest where long carriage enhances cost of the better article.

It has, moreover, been found that some of the local substitutes withstand best alternating expansion and contraction, consequent on frequent cessation of smelting.

Analyses of local substitutes are given wherever used, as a guide to the uses of theoretically inferior material.

It has been found in practice that the silica required for slagging the ferrous oxide of the converter charge, is best supplied in the form of lining, ores of a silicious character being used for this purpose. Auriferous and argentiferous linings repay cost of wastage. Barren linings add to cost and, as Professor Douglas points out, "The extra cost of the material, plus the cost of replacing it, involved in the treatment of lower, instead of high grade matte by some other method, or by changing the furnace mixture. If on the other hand, the lining consists of gold or silver or copper ore, then rapid consumption as lining may prove the cheapest way of smelting them."[1]

[1] Trans. Inst. Mining and Metallurgy, viii, 1899–1900, page 22.

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Analysis of clay from 6 miles north-westerly from Cobar, formerly used with crushed quartz and sandstone in the manufacture of firebricks for the reverberatory copper furnaces.

Chemical Composition.

No. $\frac{2081}{55}$	Moisture at 100° C	1·75
	Combined water	4·54
	Silica (SiO_2)	65·82
	Alumina (Al_2O_3)	20·74
	Ferric oxide (Fe_2O_3)	1·45
	Manganous oxide (MnO)	trace
	Lime (CaO)	·10
	Magnesia (MgO)	·97
	Potash (K_2O)	4·58
	Soda (Na_2O)	·07
	Phosphoric acid (P_2O_5)	minute trace
	Sulphur trioxide (SO_3)	·19
		100·21

Both Waratah and Lithgow firebricks were used at the commencement of smelting at Girilambone, but a locally-manufactured article superseded both. The life of the latter was satisfactory, lasting about eight weeks in the hottest parts of the furnaces. It consists essentially of about 95 per cent. silica in the form of coarse quartz, gravel and sand, with just enough clay to bind it tolerably well. It undergoes no preparation prior to puddling. The following analysis was made of the clay separated by washing from the quartz gravel and sand:—

Chemical Composition.

No. $\frac{2081}{55}$	Water	15·02
	Silica (SiO_2)	50·50
	Alumina (Al_2O_3)	22·15
	Ferric oxide (Fe_2O_3)	6·21
	Ferrous oxide (FeO)	2·46
	Manganous oxide (MnO)	absent
	Lime (CaO)	0·30
	Magnesia (MgO)	1·04
	Potash (K_2O)	2·32
	Soda (Na_2O)	·27
	Phosphoric acid (P_2O_5)	·17
		100·44

Mount Hope firebricks are made wholly from a sandy clay obtained at a depth of about 60 feet, at a distance of 7 miles from Mount Hope, first discovered in sinking a well for water. Most refractory firebrick is made from it direct after crushing. The clay is of Tertiary age, and contains sub-angular quartz pebbles. The material was panned off, and the percentage of quartz determined, viz., quartz and sand, 68·8 per cent. Following is an analysis of the fine-clay settlings from the pannings:—

Chemical Composition.

No. $\frac{2082}{55}$	Moisture at 100° C.	·61
	Combined water	7·33
	Silica (SiO_2)	63·00
	Alumina (Al_2O_3)	25·75
	Ferric oxide (Fe_2O_3)	1·24
	Manganous oxide (MnO)	trace
	Lime (CaO)	·40
	Magnesia (MgO)	trace
	Potash (K_2O)	1·69
	Soda (Na_2O)	·14
	Phosphoric acid (P_2O_5)	trace
	Sulphur trioxide (SO_3)	·10
		100·26

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For analysis of the unwashed Mt. Hope clay see page 215.

The Waratah (near Newcastle) firebricks are so well and favourably known in local smelting works that this section would be incomplete without an analysis of the shale principally used in their manufacture. It belongs to the Permo-Carboniferous Coal Measures of the Newcastle Coal-field :—

Chemical Composition.

No. $\frac{2041}{58}$—Moisture at 100° C.	2·88
Combined water	·86
Silica (SiO_2)	65·40
Alumina (Al_2O_3)	19·01
Ferric oxide (Fe_2O_3)	5·36
Ferrous oxide (FeO)	absent
Manganous oxide (MnO)	minute trace
Lime (CaO)	·05
Magnesia (MgO)	·07
Soda (Na_2O)	·29
Potash (K_2O)	·35
Phosphoric acid (P_2O_5)	absent
Sulphur trioxide (SO_3)	·13
	100·40

Fireclay used at the Burraga Smelting Works—obtained about 2 miles distant.

Chemical Composition.

No. $\frac{2104}{58}$—Moisture at 100° C.	·25
Combined water	1·57
Silica (SiO_2)	90·52
Alumina (Al_2O_3)	4·71
Ferric oxide (Fe_2O_3)	1·91
Manganous oxide (MnO)	trace
Lime (CaO)	·34
Magnesia (MgO)	·30
Potash (K_2O)	·63
Soda (Na_2O)	.10
Phosphoric acid (P_2O_5)	·02
Sulphur trioxide (SO_3)	trace
Organic matter	,,
	100·05

Locality—Eskbank—Mixed clays used in the manufacture of firebrick at Farrant's Brick Works, Eskbank. Formerly used at the Great Cobar Syndicate's Copper Refinery

Chemical Composition.

No. $\frac{103}{59}$—Moisture at 100° C.	·40
Combined water	3·12
Silica (SiO_2)	88·80
Alumina (Al_2O_3)	5·74
Ferric oxide (Fe_2O_3)	1·12
Manganous oxide (MnO)	trace
Lime (CaO)	·20
Magnesia (MgO)	trace
Potash (K_2O)	·50
Soda (Na_2O)	·14
Phosphoric acid (P_2O_5)	·09
Sulphur trioxide (SO_3)	trace
	100·11

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As a guide to the localities of refractory materials suitable for the manufacture of firebrick, the following analyses are extracted from the Annual Reports of the Department of Mines, with the remarks by the Departmental Analyst, Mr. J. C. H. Mingaye :—

Locality—County Cumberland. (?)—(Ann. Rept., 1889, p. 46.)

Moisture at 100° C	1·45
Combined moisture	3·44
Silica	60·79
Alumina	13·20
Oxide of iron	·86
Oxide of manganese	nil
Lime	·15
Magnesia	traces
Alkalies, loss, &c.	·11
	100·00

"Remarks.—This is an excellent description of fireclay, and can be classed as equal, if not superior, in quality to the English imported article. It should prove useful for the manufacture of firebricks, tiles, &c., and perhaps might be utilised for the manufacture of crucibles. The percentage of silica is higher than that usually present in the English fireclays."

Locality—Narrabeen, near Manly.—(Ann. Rept., 1191, p. 60.)

Silica	89·45
Alumina	10·40
Oxide of iron	trace
Lime	,,
Magnesia	,,
Potash	·32
Soda	·36
Titanic acid	trace
	100·53

"Remarks.—The clay was finely ground, damped with water, and fashioned into two small bricks with sharp edges, which were, after drying, submitted to a severe heat in an assay furnace. The bricks were solid and burnt white, the sharp edges being retained. I am of opinion that this clay is suitable for the manufacture of a good description of firebrick."

Shale with Plant Impressions from Parramatta [Wianamatta Series.—J. E. C.].—(Ann. Rept., 1891, p. 61.)

Moister at 100° C.	1·05
Combined water	2·35
Ferric oxide (Fe_2O_3)	·79
Ferrous oxide (FeO)	nil
Manganous oxide (MnO)	trace
Alumina (Al_2O_3)	8·81
Silica (SiO_2)	85·35
Lime (CaO)	nil
Magnesia (MgO)	·43
Potash (K_2O)	1·48
Soda (Na_2O)	trace
Phosphoric acid (P_2O_5)	,,
Sulphuric acid (SO_3)	nil
Titanic acid (TiO_2)	trace
	100·26

"Remarks.—Experiments were conducted as to the fire-resisting properties of this clay. Bricks were made of it and burnt, also with the addition of

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25 to 35 per cent. of silica. From the results obtained, and on comparing the analysis made with those of British fireclays, I am of opinion that this clay is suitable for the manufacture of firebrick."

Locality—Towrang. White Felspathic Sandstone Rock.—(Ann. Rept., 1891, p. 61.)

Moisture at 100° C. / Combined water	4·78
Silica	80·88
Alumina	13·86
Oxide of iron	·51
Oxide of manganese	nil
Lime	·15
Magnesia	trace
Titanic acid	,,
Potash	,,
Soda	,,
	100·18

"Remarks.—This is an excellent description of fireclay, and from the large percentage of silica present, should prove very refractory."

Locality—Forster (?), Cape Hawke, North Coast.—(Ann. Rept., 1892, p. 57.)

Moisture at 100° C.	2·88
Combined water	5·95
Silica (SiO_2)	70·57
Alumina (Al_2O_3)	16·27
Ferric oxide (Fe_2O_3)	1·07
Ferrous oxide (FeO)	nil
Manganous oxide (MnO)	,,
Lime (CaO)	·13
Magnesia (MgO)	·38
Potash (K_2O)	2·20
Soda (Na_2O)	·27
Phosphoric anhydride (P_2O_5)	nil
Sulphuric anhydride (SO_3)	·41
Titanic acid (TiO_2)	nil
Organic matter	,,
	100·13

"Remarks.—Bricks made from this clay and submitted to a high heat in the coke assay furnace showed no fusion, the sharp edges being retained. The bricks appear to be of excellent quality."

Locality—Aberdare Coal-mine, Swan Bay, Richmond River. Light, grey-coloured clay, 6 feet thick.—(Ann. Rept., 1892, p. 59.)

Moisture at 100° C.	2·37
Combined water	6·07
Silica	65·17
Alumina	21·89
Ferric oxide	·19
Manganous oxide	nil
Lime	·50
Magnesia	1·03
Potash	2·02
Soda	1·16
Phosphoric acid	trace
Sulphuric acid	nil
Titanic acid	,,
Organic matter	,,
	100·40

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"Remarks.—Several small bricks, with and without the addition of Silica, were made of this clay and carefully dried, then submitted to a high heat in the coke assay furnace, with the result that no fusion took place, the sharp edges being retained. The bricks had the appearance of being excellent firebrick." [Several other analyses of this shale were made with approximate results.—J.E.C.]

Locality—Heathcote, Southern Line.—(Ann. Rept., 1893, p. 52.)

	(749)	(750)	(751)
Moisture at 100° C.	.....	1·04	1·76
Combined water	4·57	3·33	5·56
Silica	74·48	78·31	72·41
Alumina	18·93	15·29	16·70
Ferric oxide	·39	·74	·28
Manganous oxide	trace	trace	1·00 (ferrous oxide.)
Lime	,,	,,	·45
Magnesia	·72	,,	·36
Potash	1·58	.....	1·45
Soda	nil	1·29	
Phosphoric anhydride	trace	trace	trace
Sulphuric acid	,,	nil	,,
Titanic acid	,,	,,	,,
	100·59	100·00	100·00

Locality—Port Stephens. Gritty White Clay.—(Ann. Rept., 1893, p. 53.)

Moisture at 100° C.	1·84
Combined water	4·36
Silica	74·57
Alumina	16·47
Lime	·17
Magnesia	trace
Ferric oxide	1·18
Manganous oxide	trace
Potash	1·03
Soda	nil
Phosphoric acid	nil
Sulphuric acid	trace
Titanic acid	nil
	99·62

Locality—Pyrmont, Sydney. Sandstone used as firestone. Hawkesbury (Triassic) Series.—(Ann. Rept., 1894, p. 65.)

Moisture at 190° C.	·45
Combined water	1·40
Silica	87·60
Alumina	8·53
Ferric oxide	·03
Ferrous oxide	·10
Manganous oxide	nil
Lime	·60
Magnesia	·29
Potash	·28
Soda	·45
Phosphoric acid	trace
Sulphuric acid	·11
Chloride of sodium	trace
Soluble silica	·40
	100·24

For additional analyses, see Cadia and Gulf Creek Mines, pages 132 and 325.

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Limestone.

Limestone Flux, Cobar District.—Limestone is not now used at the Cobar Copper Mine. When formerly required it was obtained from the Lime-kilns about 26 miles distant towards Nymagee. A geological examination has not yet been made of the locality, but from a few specimens of fossils from the limestone it appears to be of Upper Silurian age.

Small concretionary segregated nodules of magnesian limestone occur occasionally in the slates and sandstones in the immediate vicinity of Cobar, but in too limited quantity to be of any value.

The composition of the latter has been determined in the following analysis :—

Chemical Composition.

No. $\frac{2062}{58}$.—Moisture at 100 C	·31		
Combined water	1·10		
Silica (SiO_2)	19·08	Insoluble in acids. = 27·33%	
Alumina (Al_2O_3)	6·61		
Magnesia (MgO)	·62		
Potash (K_2O)	1·02		
Soda (Na_2O)	trace		
Calcium carbonate ($CaCO_3$)	39·42	Soluble in acids. = 71·08%	
Magnesium carbonate ($MgCO_3$)	30·17		
Ferric oxide (Fe_2O_3)	1·49		
Alumina (Al_2O_3)	trace		
Phosphoric acid (P_2O_5)	minute trace		
Sulphur trioxide (SO_3)	absent		
	99·82		

A considerable outcrop of encrinital limestone occurs about 10 miles from Nymagee Copper Mine, on the Bobadah-road. It is probably of Upper Silurian age, though no identifiable fossils have yet been obtained. It is of excellent quality as will be seen by the following partial analysis :—

No. 3460.—Gangue (sand)	1·76	
Calcium Carbonate ($CaCO_3$)	97·39	CaO 54·54%
Alumina and ferric oxide	·41	
Magnesia	·20	
	99·76	

A small quantity of iron pyrites present.

Close to the Anaconda, Big Ben, and Melrose Copper Mines, near Melrose, a thin superficial deposit of pulverulent carbonate of lime occurs, resting on the slates of the locality over a small area. It appears to have resulted from local deposition. Its chemical composition has been determined as follows :—

No. $\frac{2344}{58}$.—Moisture at 100° C	·45
Organic matter	·73
Calcium carbonate ($CaCO_3$)	92·67
Magnesium carbonate ($MgCO_3$)	1·05
Silica (SiO_2)	3·34
Ferric oxide (Fe_2O_3) } Alumina (Al_2O_3) }	1·50
Sulphur trioxide (SO_3)	nil
Phosphoric acid (P_2O_5)	trace
	99·74

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Limestone used as flux at Captain's Flat (Lake George Mines) obtained about 3 miles distant, on the road towards Bungendore—Mine assay.

Lime carbonate ($CaCO_3$)	99·00	per cent.
Ferrous oxide (FeO)	·06	,,
Silica (SiO_2)	·86	,,
	99·92	

The general average of the flux is from 96 to 98 per cent.

For additional analyses of limestone flux used at Cadia, Mount Bulga, Queen Bee, Gulf Creek, see pages 131, 158, 260, and 325. For other localities—Cangai, Attunga, Warialda, Bredbo, Mingary, see pages 182, 263, 315, 332, 376, and 390.

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APPENDIX I.

Local Customs Smelting Companies.

Great Cobar, Limited.

The Refinery Works,
Lithgow, N.S.W., 1st January, 1907.

All Communications to be addressed: "The General Manager."

Tariff for Purchase of Ores.

All previous tariff notices are hereby cancelled.

1. **Smelting Charge.**—20s. per ton of 2,240 lb. dry weight for parcels weighing not less than 5 tons. Under 5 tons the smelting charge will be 25s. All parcels weighing less than 1 ton will be charged as 1 ton, and deductions will be made as if the parcel weighed 1 ton. No weighing, sampling, or assaying charges will be made on any parcel, except as per clause 25.

Deductions per ton of 2,240 lb. dry weight and payment for metals as follows:—

2. From Gold.—Deduct first pennyweight, and pay at the rate of £3 15s. per oz. for the balance.

3. From Silver.—First 3 oz. deducted 1s. 3d. per oz. paid for the balance.

4. From Copper.—Deduct one unit on wet assay from containing up to and including 10 per cent. copper, one and a quarter unit from 10 per cent. and including 20 per cent., one and a half unit from 20 per cent. and including 30 per cent., and two units from ore containing over 30 per cent. copper. Copper to be paid for at the company's latest quotation for standard copper, less 2s. 6d. per unit, such quotation being the one received during the week in which the sampling is finished.

5. All ore to be delivered at the works free, but it can be arranged that freight may be charged to the works and afterwards be deducted from account sales.

6. Before receiving any ore for treatment, we require to be supplied with a fair representative sample of the ore (weighing not less than 50 lb.) which it is proposed to despatch to us. If analysis shows that the sample contains arsenic, bismuth, antimony, lead, or zinc, we are not prepared to buy such ore; and we also wish to make it clear that ore despatched to us must be according to sample in regard to being free from the metals named above, or we will refuse to take delivery of it, or if delivery has been taken and any of the above objectionable metals are found in the ore on sampling we will not accept the ore as per clause 25.

7. Railage and all charges on preliminary samples must be prepaid, otherwise we will not accept delivery of same.

Method of Sampling Ore.

8. The company does not guarantee to keep parcels separate from others after weighing and sampling, and parcels once mixed cannot be claimed by seller. The portion that is drawn for sampling as described in clause 11 is always retained until assays are agreed, and when occasion requires this portion can be re-sampled on condition named hereafter (clause 13). When the company's assay is taken without checking (clause 17) the portion referred to is kept for one week after account sales have been posted, and is then sent to the furnaces.

9. Tare of bags and actual weight of moisture to be deducted from weight of parcel.

10. Moisture sample to be taken at the commencement of the weighing and sampling operation.

11. The sample is made by taking each fifth or tenth bag, or if the ore is in bulk from each fifth or tenth shovelful.

12. To gain accuracy of results, the portion so drawn is first divided into two equal parts, which are called "first" and "second" samples, each of these parts is considered as a separate sample, are separately crushed finer if necessary, and each sample is divided into three parts, to be disposed of as follows:—

A.—One of each is to be retained by the company for assay.

B.—One of each is to be placed at the disposal of the seller.

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C.—One of each is to be sealed with company's seal, and if representative is present with his seal also. These are to be considered as umpire samples, which remain in the care of the company until it is sent to the agreed on umpire.

13. In the event of the assay results of the "first" and "second" samples not comparing closely, either party has the option, subject to clause 8, of calling for a re sample at his own expense, but such call must be made *prior to exchange of assays*, and the difference in the assay result upon which the demand is based must be declared by the party calling for the re-sample.

14. Should a re-sample take place the results of all previous samplings will become null and void.

15. The actual cost from any variation from the above methods of sampling or assaying made at the seller's request is to be borne by the seller.

16. The determination of gold and silver to be by fire method, and for copper, by either the iodide method or electrolytic copper essay. Results obtained by cyanide will not be accepted. Seller's attention is drawn to this point, and in the case of an umpire assay, the assayer making the assay is required to certify as to the above methods being followed in determining the gold, silver, and copper in the sample.

17. The seller is given the option of accepting the company's assay results as final without checking, or of settling on the mean of his and the company's assay, subject to the limit of difference named below.

18. The seller must declare before or at the sampling if he wishes a seller's sample, otherwise the company's assay alone is to be taken as the basis of settlement.

19. If the seller takes the seller's sample he must produce the assay results of both "first" and "second" samples, when settlement will be made on the mean of the company's assay of "first" and "second" samples and the mean of the seller's assay of "first" and "second" samples, subject to limits of difference and arrangements for umpiring.

20. If the seller does not wish to assay his samples they must be returned to the company with the seals unbroken before the company declares its results.

21. If the respective mean results of "first" and "second" samples agree within 1 dwt. gold, 2 oz. of silver, or one quarter of 1 per cent. of copper, the mean of buyer's and seller's assays are taken for settlement.

22. When greater differences occur they may be divided by mutual agreement, but either party may demand the umpire's samples be submitted for assay to an umpire mutually chosen. Then the average of the two nearest assays of the three is to be accepted as final by both sides.

Example :—

	First.	Second.	Mean.
D—Seller's assays, copper	10·0%	11·0%	10·5%
Buyer's assays, copper	10·5%	10·7%	10·6%
Mean assay for basis of settlement			10·55%
	First.	Second.	Mean.
E—Seller's assays, copper	10·0%	11·0%	10·5%
Buyer's assays, copper	10·7%	11·1%	10·9%
Umpire's assays, copper	10·3%	10·9%	10·6%
Mean of umpire's assay and nearest to umpire for settlement			10·55%

23. The cost of the umpire's assay is to be borne by the party whose assay is furthest from that of the umpire.

24. The preliminary samples are not kept by the company, they being samples to determine in the first instance if the ore is suitable.

25. Ore found on sampling to contain lead, arsenic, antimony, bismuth, or zinc, in any proportion, the company will not accept, and the sender will be required to pay for all actual expense incurred in unloading, sampling, and assaying such ore.

26. The seller or his representative may be present at the unloading, weighing, and sampling of his ore, provided written notice of his intention to do so is received previous to arrival of ore, but if any extra expenses are incurred by reason of delay so caused, they must be borne by the seller.

27. When despatching ore in bulk or in bags, the company must be notified of truck numbers, and the sender must state the number of bags if the ore is sent bagged.

28. Address all correspondence to "The General Manager," to save the delay which may arise through letters being addressed by name.

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English and Australian Copper Smelting Works, Waratah, near Newcastle.

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29. Consignors are reminded that they must load the railway trucks to within 5 per cent. of their marked capacity to get the lowest freight charges from the Railway Department, and to declare the value of the ore. Consignments of ore should be addressed and ticketed "Great Cobar, Limited, Eskbank." If the value is not known, consign as "crude ore under £20 per ton"; but the seller must pay any additional freight if the ore comes under the higher railway rates for ore.

30. The weight delivered over the company's scales is to be accepted as final, whether seller or his representative is present or not.

G. H. BLAKEMORE, General Manager.

English and Australian Copper Company, Limited. Established 1851.

Branch Works: Waratah and Newcastle, New South Wales. Chief Office in Australia Port Adelaide, South Australia. London Office: 17, Gracechurch-street, E.C.

This company purchases copper ores and mattes in any quantities, paying for the copper contained, as shown by assay, at 1s. per unit less than the latest telegraphed price of standard copper in London, "spot" or "three months" at the company's option.

When the ore does not contain impurities (such as arsenic, bismuth, &c.), and the company considers the copper of sufficiently good quality to bear its "P.C.C." brand, a special allowance of 6d. per unit (£2 10s. per ton of copper) will be made.

The charge for smelting varies, according to the nature of the ore and other circumstances, but does not exceed 45s. per ton of 21 cwt., except in the case of especially refractory ores.

No charge will be made for weighing, sampling, or assaying when the parcel weighs 42 cwt. or over.

All purchases of ore (and matte) are made subject to the following conditions, unless other arrangements are agreed upon previous to arrival of the ore at the works:—

1. Ores are purchased delivered at the company's works, Waratah, N.S.W., but sellers can arrange for railway carriage or freight to be paid by the company, and deducted in account sales.
2. Three samples will in all cases be taken; one to be retained by the seller, one by the company, and the third to be sealed and kept as a reference sample.
3. The seller or his representative may be present at the weighing and sampling, provided notice of his intention to attend is received before the ore has been sampled.
4. When the seller's assay differs from that of the company, the difference will be divided, provided it does not amount to more than 1 per cent. of copper; if greater, the reference sample will be submitted to an independent assayer (to be selected by agreement), and payment made on the middle assay of the three.
5. Ores, &c., are weighed 21 cwt. to ton, as customary in the copper smelting business.
6. The company pays for the whole of the copper contained in the ore; as shown by fire assay. When seller's assays are made by wet method the following deductions will be made from the results so obtained:—

Ores assaying	12 per cent. or under			deduct	1 per cent.
,,	,,	over 12 and under 20	per cent.,	,,	1¼ ,,
,,	,,	20 ,, ,,	35 ,,	,,	1½ ,,

7. In the case of parcels less than 21 cwt., a charge of 20s. will be made for sampling and assaying, and a similar charge of 10s. in the case of parcels of 21 cwt. and less than 42 cwt.
8. The date upon which the sample is taken will be considered to be the date of purchase of the ore.
9. Payment by cheque immediately assays are agreed.
10. Other conditions as usual in the copper smelting business.

The company reserves the right to make special terms and arrangements for large parcels or regular consignments and to refuse ores containing an extraordinary quantity of bismuth or other metal which affects the quality of ore.

Any further information required will be supplied on application to this office; to the Manager, Port Adelaide, S.A.; or to the company's agent in West Australia.

All previous tariffs are cancelled.

THOMAS JOHNSON, Manager, New South Wales Branch.

Waratah, N.S.W., July 13, 1908.

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The Melbourne and Great Northern Smelting Company, Limited.

Works: Waratah, near Tighe's Hill, Newcastle, New South Wales.

Tariff for Copper Ores and Mattes.

The company will purchase copper ores and mattes in any quantities, and act as Customs smelters, on the following terms:—

Delivery at works, Tighe's Hill, Newcastle, New South Wales. Consignors can arrange to have railage or sea freight paid by works and deducted from returns.

Weights.—The net dry weight as shown by the company's tested scales, at the rate of 21 cwt. to ton, will be taken as basis for payment.

Moisture samples will be taken at time of weighing and the moisture ascertained in usual way.

Tare of bags.—When ore is in bags, these will be weighed on same bridge, in order to ascertain the tare of bags to deduct.

Assay samples according to the ore.—Sampling will be done by quartering down the whole or a fraction of each parcel, by taking a specified number of bags from the lot, and quartering these. This may be done automatically or by hand. The final sample will be divided into three equal and similar proportions—one for buyer, one for seller, and one will be sealed up for umpire.

Agreement of assays.—For copper differences of 1 per cent., for gold differences of 1 dwt., and for silver differences of 1 oz., will be split. When differences exceed these limits, the assay will be referred to umpire. The agreed assay shall be the mean of umpire's result, and that nearest his result. The party whose result is furthest from umpire will pay cost of umpire assays.

Deduction from wet assay of copper.—When copper is determined by wet methods, the following deductions will be made:—

Ores assaying under 10 per cent.		1 unit.
,,	,, over 10 and under 20 per cent.	1¼ units.
,,	,, over 20 and under 35 per cent.	1½ units.

Gold and silver assays, when necessary, will be charged 5s. each, and made by fire and scorification methods.

Bags.—Used bags will be returned to customers free of railage.

Payment for gold and silver will be made when either of both are present in sufficient quantities to pay for cost of extraction.

If the ore, which is consigned to this company, contains no impurities such as arsenic, bismuth, tin, lead, or antimony, &c., and can be refined into a first-class copper, an additional allowance of 6d. per unit will be made to the consignor.

Impurities.—Ores found to contain deleterious impurities in sufficient quantities to impair the value of the resulting metal, will be penalised in proportion to quantities contained.

Representation.—All weighing and sampling can be witnessed by seller's representative.

The ore will be weighed and sampled as soon as possible after arrival at the works. Should the consignors or representatives wish to be present at the weighing and sampling notice must be given, and then an appointment will be arranged.

The date on which the ore is weighed and sampled will be considered the date of purchase.

Returning charge will be £2 5s. per ton of dry ores, weighed as specified higher up (Clause 3). Lower terms may be arranged for specially suitable ores in large quantities.

Price basis for copper.—The latest cabled price before, or on sampling day, will be taken as basis price of copper. Unless otherwise arranged, the price of forward standard copper will be taken, less a deduction of 1s. 3d. (one shilling and threepence), per unit.

Discharging and sampling will be charged for at 1s. 6d. per ton.

Assaying.—No charge will be made for assaying for copper.

Draftage.—No draftage deduction will be made.

Payments will be made by cheque as soon as weights and assays are agreed upon.

The company reserve themselves the right to refuse ores of unsuitable nature, or to vary this tariff for specially good or bad smelting ores. In such case due notice will be given seller, in order to avoid expense to him.

The company will receive and examine parcels of ore of about 10 lb. weight from intending customers, and will advise them free of charge as to the returning charges for similar ores in larger lots.

All communications to be addressed to the Manager, Melbourne and Great Northern Smelting Company (Limited), Tighe's Hill, Newcastle, New South Wales.

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Blayney Copper Mines and Smelting Company, N.L.

Mines and Works, Blayney, New South Wales,
2 September, 1907.

Head Office : 375 Collins-street, Melbourne ; Sydney Office : Australasia Chambers, Martin-place.

All previous tariff notices are hereby cancelled.

Smelting charge.—Twenty-five shillings per ton. Parcels weighing less than 1 ton will be charged, and deductions made as if the parcel weighed 1 ton.

Weighing and sampling.—A uniform charge of £1 will be made on all parcels irrespective of weight. Metal deductions and prices at per ton of 2,240 lb. net dry weight.

Copper.—From ore assaying by wet method :—

Up to 10 per cent.											Deduct	1¼	units.
Over 10 per cent. up to and including 15 per cent....											,,	1½	,,
,,	15	,,	,,	,,	20	,,	...				,,	2	,,
,,	20	,,	.....								,,	2½	,,

Price.—Net copper contents as determined above to be paid for at the latest London quotation for standard copper, "spot" or "three months" at the company's option, less 2s. 6d. per unit, such quotation being the average for the week in which sampling is finished.

Gold.—Deduct 2 dwt. Balance paid for at 80s. per ounce.

Silver.—First 3 ounce deducted, balance said for at 1s. 6d. per ounce.

Penalties :—

Arsenic and, or antimony, 2s. 6d. per unit.
Zinc, up to 5 per cent., nil ; over 5 per cent., 1s. per unit.
Lead, up to 5 per. cent., 1s. per unit. Ores containing more than 5 cent. lead will not be purchased.
Bismuth.—Ores containing bismuth will not be purchased.

Payment.—Cash on agreement of assays.

Special notice.—Before sending parcels to the works, producers should forward a representative sample (about 50 lb.), and it must be clearly understood that the parcel will be up to sample as regards freedom from bismuth and lead (above 5 per cent.). Should the parcel prove to contain bismuth, and (or more than) 5 per cent. lead, the company will refuse to accept delivery.

Conditions of purchase.

1. Ores will be purchased, freight paid, at the company's works, Annandale Siding, near Blayney, New South Wales. By previous arrangement, rail freight will be advanced by the company, and amount deducted on account sales.

2. Weighing and sampling at the company's works.—The seller, or his representative, may be present, provided that written notice of his intention to do so is received previous to arrival of ore. The company, however, guarantees correct weighing and sampling in all cases.

3. All ores weighed at 20 cwt. to the ton of 2,240 lb. ; weights, as delivered over the company's scales, to be final.

4. Three samples will be taken : one for the buyer, and one for the seller, and the third to be sealed and kept as a reference sample. Differences of more than one quarter of 1 per cent. copper, 1 dwt. gold, or 2 oz. silver, require that the reference sample shall be assayed. Average of reference assay and one nearest to it will be taken as basis for settlement. The party whose assay is farthest from the reference to pay the cost of the latter.

5. Either party has the option of calling for a re-sample prior to exchange of assays. Should a re-sample take place, the results of all previous samplings will become null and void.

6. The determination of gold and silver to be by fire method, and for copper by either the iodide method or electrolytic copper assay. Results obtained by cyanide will not be accepted. Seller's attention is drawn to this point ; in the case of an umpire assay, the assayer is required to certify as to the above methods being followed in determining the gold, silver, and copper in the sample.

7. If no word is received from the seller previous to assaying, the company's assay results are to be final.

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8. If the seller does not wish to assay his samples they must be returned to the company with the seals unbroken before the company declares its result.

9. The company does not guarantee to keep parcels separate after weighing and sampling, and parcels once mixed cannot be claimed by seller.

10. All other conditions as usual.

Consign to Annandale Siding.

Advise Company of truck Nos., number of bags, and distinguishing marks (if any).

F. L. PIDDINGTON, General Manager.

The Electrolytic Refining and Smelting Company of Australia (Limited).

Works in Process of Construction.

Port Kembla, N.S.W.,
21 April, 1908.

The plant will consist of a tank-house, a furnace refinery, silver and gold refinery, a smelter and converter plant, and all other buildings necessary for a plant of this description. The electrolytic plant will consist of 360 tanks, approximately 10 ft. x 3 ft. 6 in. x 3 ft. 6 in., and will be capable of treating between 35 and 40 tons of blister copper per day.

The furnace refinery will consist of two 100-ton reverberatory copper-refining furnaces, equipped with mechanical casting wheels, capable of casting 25 or 30 tons of copper per hour.

The smelter will consist of reverberatory smelting plant capable of treating 150 tons of ore per day, and the converter plant will consist of two 10 ft. 6 in. x 7 ft. 6 in. electrically operated converters. This plant will be capable of converting 60 tons of 45 per cent. copper matte per day.

The power-house will consist of two 550 k.w. electrolytic generators at 150 volts, two 150 k.w. power generators at 250 volts; one turbo-blower for converters, running at 8,500 revolutions, and capable of compressing 3,500 cubic feet of air against 15 lb. pressure. This power-plant will also contain air-compressors compressing to 30 lb. of air-pressure, and to 80 lb.; the latter for operating air lifts to be used throughout the plant.

All transportation between buildings will be conducted by means of electric locomotives.

The feeding of the reverberatory furnace will be automatic. The boiler-house will consist of five large Babcock and Wilcox boilers, complete with all modern appliances. This plant will be absolutely free of all labour, as the coal received on a high line is discharged into a bin, which directly feeds into the hoppers of the automatic stokers.

The load factor of our power plant will be about 98 per cent., and it is expected that our power will be generated at ½d. per k.w. hour.

The plant will give employment to about 250 men, and we expect to begin operations in the smelting department by December of this year.

Provision is also made for the installation of a blast furnace, which will be built if the Government will make wharfage rates which will enable us to carry into this port low grade copper ores from the Australian States, and from foreign ports.

The plant will use not less than 14,000,000 gallons of water per year, and the success of the plant is in a large manner dependent on an ample water supply. At the price we pay the Government for water the Government will derive 1s. 6d. on the sale of water for every ton of material treated in this plant.

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APPENDIX II.

SOUTHERN MINING DISTRICT—*Nowra Division.*

Ettrema Lodes (*see* page 345).

The highest deposit in Ettrema Creek bed, though not the highest of the series, consists of a bed of quartzite impregnated with mispickel—chiefly zinc-blende, galena, and chalcopyrite. The actual thickness is not exposed, but several feet are revealed. A representative sample chipped from the exposed faces and broken material yielded :—

No. 08-2589—	Arsenic	17·37 per cent.
	Zinc	10·55 ,,
	Lead	6·20 ,,
	Copper	1·42 ,,
	Gold	a few grains per ton.
	Silver	8 oz. 13 dwt. 3 gr. per ton

A lower deposit further down the creek forms the apex of an anticlinal fold, with a pitch N. 20° W. The exposed thickness is about 25 feet, but the base is not visible. Zinc blende predominates in this deposit. A representative sample from the face and from broken material from a small opening yielded :—

No. 08-2590—	Zinc	28·12 per cent.
	Lead	8·90 ,,
	Arsenic	3·77 ,,
	Copper	1·60 ,,
	Gold	a few grains per ton.
	Silver	9 oz. 14 dwt. 22 gr. per ton.

From a still lower deposit, apparently cutting across the bedding, a representative sample yielded :—

No. 08-2591—	Zinc	22·79 per cent.
	Copper	0·15 ,,
	Lead	none detected.
	Gold	a few grains per ton.
	Silver	18 dwt. 12 gr. per ton.

It is apparent that, as is usually the case, the silver is associated with the lead ore.

It is further evident that the principal value of the deposits is in zinc. Doubtless a considerable proportion of zinc-blende could be roughly classified to commercial grade, but the great bulk would require both concentration and separation.

Possibly a double process may be devised by which both zinc and arsenic may be successively sublimed as commercial products, leaving a cupriferous residue, freed from these highly injurious associates.

The silver-lead ore could also be roughly classified into a smeltable product, leaving a residue so small as to be negligible in the other processes.

The composition of the best limestone is shown in the following partial analysis :—

No. 08-2588—	Carbonate of calcium	86·07
	Carbonate of magnesium	1·13
	Ferric oxide and alumina	2·16
	Insoluble	10·44
	Moisture at 100° C.	·23
		100·03

Talwong Mine (*see* page 367). Examined 27 July, 1908.

The Talwong lode varies from a few inches to over 8 feet in thickness, and dips apparently S. 65° W. at 30°. Where it traverses rigid quartzite strata it makes strongest, the pinches naturally occurring in the more yielding slates.

It outcrops on both sides of a precipitous gorge which has dissected it roughly in the direction of the dip.

By three tunnels, from 27 to 57 feet in length, and numerous shallow cuts, the lode has been exposed for a length of 2,283 feet. The highest opening above the Shoalhaven River is 770 feet, the lowest about 200 feet.

The principal lode material, where it makes solid, appears to be mispickel (arsenide of iron), but the unexpected presence of tin sulphide (stannine) in the 37 feet tunnel at No. 6 opening renders further examination throughout necessary for determination of

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that mineral in other portions of the lode. The copper had previously been determined in the ore from this opening, but not the tin, until the Writer submitted an average sample to the departmental laboratory, when its presence was detected and the amount determined.

The presence of tin ore in sedimentary rocks at Talwong at some distance from granite is of interest. It is probable that felsitic contemporaneous rocks may be included in the former which have not yet been carefully examined.

Fluor-spar, in rich emerald-green masses, also occurs at intervals.

Galena and zinc-blende are present in parts of the lode, but the aggregate proportion is small, especially the zinc-blende.

An average sample of the best copper ore from all openings, including the stannine, yielded :—

No. 08-2592—Copper	.....	10·23 per cent.
Tin	.....	2·10 ,,
Arsenic	.....	8·78 ,,
Gold	.....	a few grains per ton.
Silver	.....	2 oz. 15 dwt. 13 grs. per ton.

This sample consisted chiefly of ore showing chalcopyrite.

An average sample selected from all openings yielded :—

No. 08-2593—Copper	.....	6·12 per cent.
Tin	.....	2·30 ,,
Arsenic	.....	15·80 ,,
Gold	.....	a trace.
Silver	.....	2 oz. 9 dwt. 0 gr. per ton.

A sample carefully averaged from a considerable quantity broken from a 7 feet face in the 37 feet tunnel at No. 6 opening, and from the stack of mineral raised in driving it, yielded :—

No. 08-2594—Metallic copper	.....	14·13 per cent.
,, tin	.....	10·26 ,,
,, arsenic	.....	0·96 ,,
Gold	.....	a few grains per ton.
Silver	.....	1 oz. 8 dwt. 7 grs. per ton.

Talwong mining is only in the initial stage of preliminary development with a view of determining method of treatment, &c. Hitherto arsenic has been regarded as the primary product to be recovered in form of commercial oxide in preliminary roasting, and doubtless, from this strong and permanent lode, it can be obtained in quantity. The presence of both copper and tin as residual products after expulsion of the highly deleterious associate, arsenic, gives a higher value to the ore, though its metallurgy will be complex and difficult.

Careful preliminary classification may result in the copper-tin ore being kept fairly free from arsenic.

It is desirable that further prospecting, and careful assay tests, be carried out for the purpose of locating the stannine makes in the lode, and ascertaining their prospective proportions.

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APPENDIX III.

Prepared by W. R. COLLIS.

Methods of acquiring Titles to Prospect or Mine for Copper on Crown Lands. (Mining Act, 1906.)

The Mining Act, 1906, provides that the term "Crown Lands" shall include lands vested in His Majesty, lands held under lease from the Crown, except conditional leases, conditional purchase leases in terms of the Crown Lands Acts, or leases granted under the Mining Act, 1906; also lands reserved, dedicated, appropriated, or resumed for public purposes, whether vested in His Majesty or in any person as constructing authority or trustee; lands under navigable waters, or under any harbour, estuary, bay, river, or creek vested in His Majesty, whether navigable or not, and any lands which the Governor may declare by proclamation to be Crown lands.

Crown lands.—Certain classes of Crown lands are, however, exempt from occupation as mineral prospecting areas or claims under miners' rights, viz., lands reserved, dedicated, or appropriated or resumed for public purposes (excepting lands reserved for a temporary common, or for mining or mining purposes) whether vested in His Majesty or in any person as constructing authority or trustee for public purposes, residential leases, settlement leases, or special leases for purposes other than pastoral or grazing purposes; lands held under lease for water supply, in virtue of any special Act or otherwise; lands granted or vested in trust by the Crown for the purpose of a racecourse, cricket ground, recreation reserve, park, permanent common, or for any other public purpose, and lands the subject of a pending application for lease under the Mining Act, 1906.

Prospecting area.—The holder of a miners' right may mark off Crown lands, not exempt from occupation as above, to the extent of 40 acres, for the purpose of prospecting for copper. One man at least must be continuously employed, and the discovery of payable mineral must be reported to the local Mining Registrar within seven days, and within twenty-eight days from the date of the report the prospector must mark off a "reward" claim within his prospecting area, not exceeding 10 acres, or apply for a mineral lease. Any other miner may mark off an ordinary mineral claim not exceeding 4 acres, within the balance of the area.

The term "payable mineral" means sufficient mineral to pay current wages to the men employed on or in connection with the claim. The onus of proof that the mineral obtained is not payable, rests with the prospector.

One person may hold more than one prospecting area, but an additional miners' right must be held for each additional area, and each area must be represented by the proper amount of labour.

Authority to prospect.—Application may be made to the Minister by the holder of a miners' right, for authority to prospect on Crown lands, whether ordinary Crown lands or lands exempted from occupation under a miners' right, as above. Such authorities are granted on the recommendation of the Prospecting Board for a limited term, and subject to payment of such rent and the performance of such labour conditions as may be fixed by the Minister. On discovery of the copper or other minerals sought, the fact must be reported to the Warden within fourteen days; the authority-holder may then be required by the Minister to apply for a lease to cover the area, or such part as the Minister may determine, or to continue prospecting operations.

Lease.—Leases may be applied for over ordinary Crown lands, or over Crown lands which are exempt from the operation of miners' rights, excepting lands held under lease or application for lease in terms of the Mining Act, 1906.

The maximum area that may be held under one lease is fixed at 80 acres. The area must, where practicable, be measured in the form of a parallelogram, the length of which must not exceed three times the breadth. The rental is fixed at 5s. per acre per annum, and the labour conditions at not less than one man to 20 acres, or fraction of 20 acres, for the first twelve months of the term, and thereafter not less than one man to 10 acres, or fraction of 10 acres.

Leases may be granted for a period of twenty years, renewable for a like period.

Where such leases are granted over lands held from the Crown as settlement leases, residential leases, and such like tenures under the Crown Lands Acts, the holders thereof are entitled to compensation for any damage that may be done to the land by reason of the mining operations, such compensation to be assessed by the Warden and paid by such lessee.

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Methods of acquiring Titles to Prospect or Mine for Copper on Private Lands.

In cases where the Crown grants contain, or, if not yet issued, would, when issued, contain a reservation to the Crown, of all minerals in the land, the right to prospect for copper, may be obtained by applying to the local Warden for an authority to enter, with a view to applying for a lease, or an agreement to mine may, with the concurrence of the Minister, be made with the owner of the land (*see* Section 69).

Authority to enter.—An authority to enter may be granted for a period of twelve months, subject to payment of rent and compensation, to be fixed by the Warden, and to the employment of labour in the proportion of one man to 20 acres, or fraction of 20 acres. An authority may be extended by the Warden from time to time, but so as not to exceed, with the original term of the authority, a period of twenty-four months, on such terms as he may deem fit, if he is satisfied that further time is required to enable the holder to complete his prospecting operations. Applications must be lodged with the Warden's Clerk of the Division in which the land required is situated.

Lease.—During the currency of the authority the holder may apply for a lease of the area or such part thereof as he may desire. Leases may be granted for a period not exceeding twenty years, renewable for a like period, subject to the payment of rent at the rate of £1 per acre per annum, half-yearly in advance, but such rental is payable only in respect of the area of the surface leased. A royalty at the rate of 1 per centum of the mineral won, must be paid to the Crown, after deduction of the rent paid to the owner.

The labour conditions are fixed at not less than one man to 20 acres, or fraction of 20 acres, for the first twelve months of the term, and thereafter not less than one man to 10 acres, or fraction thereof.

Agreements.

The owner of land in which the minerals are reserved to the Crown, may enter into an agreement with the holder of a miners' right, allowing such holder to mine for copper or other minerals, upon such conditions as to rent and period as may be mutually agreed upon. The area must not exceed 80 acres; the agreement is subject to the concurrence of the Minister, and must not contain any provision or stipulation for payment to the owner of any sum by way of royalty on the mineral raised. A royalty of 1 per centum is payable to the Crown after deduction of the rental payable to the owner. Labour conditions, as in ordinary leases, must be complied with (Section 69).

Where the minerals are not reserved to the Crown, the owner may enter into an agreement with any person, whether the holder of a miners' right or not, allowing the latter to mine upon such land. If registered, such agreement will protect the land from application for authority to enter and prospect for gold (Section 70).

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INDEX.

PAGE.

A1 Mine 369
Aberfoyle Copper Leases 304
Acacia 100
Acacia Dam 94
Ace Mine 285
Adaminaby 383
Adeline Mine 304, 310
Adjungbilly Creek 374, 382
Albert District 90
,, Waterholes 289, 291, 292
Alexandra Mine 90
Alpine Copper Mine 90, 387
Amaroo Mine 279
Anaconda Mine 48, 84, 269
Analyses—
Clays and firebricks 325, 399-406
Attunga ore 315
,, limestone 315
Gulf Creek clay 325
Slag, Snowball 394
Captain's Flat, ore 26, 356
Clay, Cadia 132
,, Cobar 400
Cobar ores 234
,, sulphides 285
,, E.L.C. copper 244
Annandale Mine 14, 106, 111
Antimony 44
Apsley 155, 159
,, C. Mine 106, 108, 155
Arizona C. Mines 45
Arkell 110
Armidale 311
Armidale Division—
Bundarra Mine 318
Armstrong C. Mine 269
Arramagong 269
Arsenic 43
Ashes 84
Athole-Blayney C. Mine 109
Attunga C. Mine 313
,, ,, ... 328
Augusta Mine 91
Austin Mine 48
Azurite 18
Baalgammon Mine 194, 376
Bachelor's Reef 335
Back Creek 270
Backe's C. Mine 285
Balaclava I. and C. Mine 90
Balconnel G Mine 374
Bald Nob Mine 305
Balmoral C. Mine 109
Bang Bang 148
Baring 143, 148
Barraba 317, 322
Barraba Division—
Barraba District 317
Four-Mile Lode 322
Gulf Creek C. Mine 322
Ironbark Lode 326
Murchison Lode 328
Spring Creek C. Mine 329
Wilpina C. Lode 333
Woods Reef 333
Barrier S. and C. Mine 91
,, Queen C. Mine 91
,, Ranges 91
Bates' Lode 305
Bathurst Division—
Apsley C. Mine 106
Esmeralda C. Mine 142
Green Swamp C. Mine 144
Jones' Mine 148
Locksley 150

PAGE.

Bathurst Division—*continued.*
Mount Morris Lode 159
Mountain Maid Lode 154
Red Hill Mine 166
Belara C. Mine 286
,, ... 299
Bell River 270
Bell View Mine 351
Belmore C. Mine 109, 270, 374
Belubula 175, 274, 275
,, C. Mine 110
Berridale 375, 388
Besshi 85
Black Jack Range 379
Black Lead 92
Black Mount Mine 110
Blakemore, G. H. 86, 241
Blayney 106, 109, 111, 114, 166, 170
,, C. Mine 14, 20, 111
,, ... 113
Blayney Division—
Annandale S. and C. Mine 106
Athole Blayney C. Mine 109
Blayney C. Mine 111
Blayney District 114
Diamond Hill 141
Guyong 141
Newbridge 160
Quigley's Hill C. Mine 166
Rise and Shine Mine 167
Sugarloaf C. Mine 170
Blue Bell Mine 270
Blue Creek 375
Big Ben C. Mine 270, 277
Big Wertago Mine 92
Binalong 270
Binalong Division—
Murrumbidgee C. Mine 365
Spion Kop Lode 367
Bingara 317, 329
,, Upper 326, 331
Bingara Division—
Bobby Whitlow 317
Borah Creek C. Mine 318
Harrison's Mine 326
Hilda May C. Lode 326
Mandourie Paddock 327
Mona C. Lode 327
Mount Lauff C. Lode 327
Prince of Wales C. Mine 329
Spring Creek 329
Sweet Nell C. Lode 331
Warialda 332
Birdite Mine 98
Birrama 365
Bismuth 42
Boambola 366
Bobadah 194, 217
Bobadah Division—
Emerald 217
Long Panel Lode 248
Recovery C. Mine 261
Walker's Hill 262
Yellow Mount 262
Bobby Whitlow Mine 317, 329
Bobs Mount 114
Bodangora 291
Bogan R. C. Mine 288
Bogong C. Mine 376
Bolairo 101
Bolderogery 372, 373
Bombah 174
Bonnie Dundee Mine 194
Boomerang Hill 95
Boone West 269

Digitized by Google

INDEX—*continued.*

PAGE.

Boori C. Mine 271
Boppy Mount 194
Borah Creek C. Mine 318, 320
Border Chief Mine 305
Boree Nyrang 273, 281
Bornite 18
Boro C. Mine 335
Bourke Division—
Doradilla C. Lode 216
Bowan Park 271
Bowenbang Creek 289
Bowling Alley Pt. 318
Brady's 93
Braidwood 335, 336, 361, 363, 364
Braidwood Division—
Boro C. Mine 335
Mount Fisher C. Lode 363
Mulloon C. Mine 364
Breadalbane 389
Bredbo 376, 377
Britannia Mine 115
Broken Hill 93–96
,, Proprietary Mine 93
Broken Hill Division—
Alexandra Mine 90
Alpine C. Mine 90
Balaclava I. and C. Mine 90
Barrier Range 91
Barrier S. and C. Syndicate 91
Birdite Mine 93
Black Lead 92
Broken Hill Proprietary S. Mine 93
Copper Blow Mine 97
Copper King Mine 97
Diamond Jubilee Mine 98
Fairy Hill 99
Federal C. Mine 99
Florence Mine 99
Glencoe Mine 99
Hampton C. Mine 100
Hornsby Range 100
Invincible C. Mine 100
Lady Hampden Mine 101
Mootwingee C. Mine 101
Nadbuck C. Mine 101
Orient Mine 102
Paragon Lode 102
Pinnacles 103
Ponto Mine 103
Purnamoota 103
Red Flag C. Mine 103
Rockwell Paddock 103
Ruby C. Mine 103
Silverton 104
Broula 271, 276
Brown's Creek 115, 167
Brungle 377, 378
Buckenbah 370
Buckley's Crossing 378
Budgery C. Mine 13, 194
Budgerygar Mine 195
Bullio 336
Bull's Creek 116
Bumbaldry 271, 274
Bumbery C. Mine 271
Bundara Mine 318
Bundundah 337
Bungiebomar 289
Bungendore 363
Bungonia 337
Bunker's Hill Mine 96
Buppe C. Lode 196
Burra Burra 14, 65
Burraga 80, 117–126, 142, 401
Burraga Division—
,, C. Mine 117
,, (Lloyd) C. Mine 117
Mount Burraga 169
Sprague's Mine 169
Burril Ranges 290
Burly Jacky C. Mine 116
Burnt Yards 151
Burrowa 272, 335, 354, 360

PAGE.

Burrowa Division—
Binalong 270
Bachelor's Reef 335
Lang's Creek Mine 360
Mayfield C. Mine 362
Wallah Wallah C. Mines 365
Busy Bee C. Mine 180
Butte C. Mines 25, 59, 81
Byng 126, 134, 146, 147, 161, 166
C.I.A. Mine 13
Cadia 175
,, C. Mine 127–132
,, Extended C. Mine 132
Cahfat 395
Camel Back Mountain 187
Cambelego 194–198
,, C. Mine 198
Cambelego Division—
Baal Gammon Mine 194
Bounie Dundee Mine 194
Boppy, Mount 194
Budgery C. Mine 194
Buppe C. Lode 196
Cambelego C. Mine 196
Shango Mine 197
Cambelego North 197
,, Peak 197
,, Queen 197
Hermidale 347
Mount Boppy C. Mine 348
North Shango 197
South Budgery 267
,, Mount Boppy 267
Cangai C. Mine 180–181
Canning and Gibson's Mine 357
Canobias C. Mine 132
Canowindra Division—
Belubula C. Mine 110
Copper Mine Creek 274
Eurow C. Mine 274
Fitzroy Mine 275
Sugarloaf 170
Vychan C. Mine 253
Capertee 300
Captain's Flat 337, 346, 354, 406
Captain's Flat Division—
Canning and Gibson's Mine 337
Federal Mine 346
Grogan and Singleton's Mine 353
Lake George Mine 354
Carangara C. Mine 134
Carcoar 135, 137, 170
Carcoar Division—
Coombing Park C. Mine 137
Infirtaris C. Mine 147
Kemp field 149
Summer's C. Mine 170
Cargo 273
Caroline C. Mine 300
Carwoola 391
Cash Essington Mine 196
Casino Division—
Jones' Lode 189
Just in Time Lode 190
Minnie C. Lode 191
Nil Desperandum Lode 192
Nogrigar Lode 192
Wallaroo Lode 193
Castle Hill C. Mine 305, 306
,, C. Lode 306
,, Rag 306
Chandler River 330
Cheeseman's Creek 273
Cheshire C. Mine 389
Chillagoe 66
Chisholm's C Mine 355
Chris. Watson Mine 220
Christmas Gift Mine 389
Clarence River 187
Cliefden 170
Cobar 222
,, Chesney G. and C. Mine 198
,, C. Ltd. 199
,, Gold Mines 221

Digitized by Google

INDEX—*continued.*

PAGE.

Cobar—Lyell Mine 211
,, Tharsis 210
Cobar Division—
Cobar Chesney 198
,, Tharsis 210
,, Gold Mines 211
East Cobar Mine 216
Gladstone Mine 226
Great Cobar Mine 228
,, ,, N. Mine 228
Mallee Tank 210
Occidental S. Mine 258
Queen Bee C. Mine 259
S. Queen Bee Mine 261
Tindary 210
Collector Division—
Currowang C. Mine 341
Donnelly's Mine 344
Commonwealth Mine 308
Comstock C. Mine 319
Concentration 44
Condobolin 270, 282
,, C. and G. Mine 273
Condobolin Division—
Anaconda Mine 269
Big Ben C. Mine 270
Blue Bell Mine 270
Condobolin C. and S. Mine 273
Melrose C. and G. Mine 277
Mt. Susannah C. Lode 279
Phœnix Mine 281
Ramping Lion Lode 282
Rifle Butt Mine 282
Sultan C. and L. Mine 283
T.W. C. Lode 283
Congwarra 377, 379
Conjola Creek 338
Conjuror Mine 351
Conqueror 210
Conrad Stannite Mine 320
Cooma 377, 378, 380
,, C. Mine 377
Cooma Division—
Berridale 375
Bredbo C. Mine 376
,, District 377
Cooma C. Mine 377
Cootralantra 378
Dartmoor C. Mine 380
Dyball's C. Mine 388
Gegedzerick 381
Fiery Creek G. and C. Mine 381
Jindabyne C. Mine 382
Kyloe C. Mine 383
Macanally G. and C. Mine 388
Monaro C. Mine 388
Monmouth C. Mine 389
Nithholm C. Mine 390
Rosebank 392
Snowy River 378, 394
Wambrook 396
Coombing Park C. Mine 137
Cooperacurripa C. Mine 320
Cootamundra 273, 278
,, G. and S. Mine 279
Cootamundra Division—
Mt. Felstead C. and S. Mine 278
Cootra Mine 101
Cootralanta 378, 381
Copelsond Division 319
Comstock C. Mine 319
Cope's Creek 320
Copeton 327
Copmanhurst 180
Copmanhurst Division—
Busy Bee Lode 180
Cangal C. Mine 180
Camel Back Mountain 187
Fine Flour Mine 187
Flintoff's C. Lode 188
Gem Mine 189
Glamorgan C. Mine 189
May Queen Lode 190
Pluck Mine 192

PAGE.

Copmanhurst Division—*continued.*
Potato Creek 93
Walker's Pinch Lode 193
Wiley's Lode 193
Yulgilbar 193
Copper Blow Mine 97
,, Gully 326
,, Hill 6, 7, 129, 276
,, ,, Mine 138, 289
,, King Mine 97
,, Mine Cave 304
,, ,, Creek 274
,, Well Mine 97
Coramba Division 191
Mount Browne C. and S. Mine 191
Corbould, W. H. 30, 58
Cordillera Hill 140
Cornish Settlement 134
Coronation Mine 379
Corrowong C. Mine 379
Cow Flat 109, 148, 141
,, C. Mine 140
Cowfell Mine 274
Cowley C. 377, 379
Cowra 141, 147, 280
,, Mine 176
Cowra Division—
Broula 271
Burley Jacky C. Mine 116
Holmwood C. 147
King of England Mine 276
Waugoola Creek C. Mine 175
West Hill C. Mine 175
Coyle's Mine 339
Crowl Creek 211
,, ,, C. Mine 215
Cu Copper Mine 188
Cudal Division—
Bowan Park 271
Bumbery C. Mine 271
Cheeseman's Creek 273
Mount Keenan Mine 279
Naugar Range 280
United Empire Mine 283
Cudgegong 309
Cullen's Creek 306
Cullerin C. Mine 339
Cumnock 231
Cupriferous Shales 62
Curra Creek 341
Currowan Creek 336
Currowong 15
,, C. Mine 341
Currumbis 290
Customs Smelting Coy's. 406-412
Cyclops C. Mine 389
Dadauman 274
Dairy Hill 273
Dalmorton Division 192
Newton Boyd S. and C. Lode 192
Dandaloo Division—
Ace Mine 285
Bogan River C. Mine 288
Chris. Watson Mine 290
Honeysuckle 291
Iron Duke Lode 291
Lady Elwyn Mine 292
Monarch Mine 292
Mount Keenan 292
Mount Pleasant C. Mine 254, 294
Mount Royal C. Mine 294
Orange Plains C. Mine 299
Sydney Wallaroo C. Mine 300
Dandaloo 285, 288, 289, 291, 294, 300
Darbalara 380, 382
Dartmoor C. Mine 380
Dawson's Mine 298
Day Bros.' Mine 226
Deepwater 305, 306
Deepwater Division—
Castle Hill C. Mine 305
Pye's Creek 311
Delaney's Dyke 274

Digitized by Google

INDEX—*continued*

PAGE.

Delegate Division—
Belmore C. Mine 374
Currowong C. Mine 379
Mount Trooper 390
Quidong 374
Democrat Mine 272
Denison Town 290
Diamond Hill 141
,, Jubilee Mine 98
Dingo Mine 143
Dinoga 331, 332
Doctor's Creek Lode 337
Dolcoath Lode 370
,, Mine 141
Dolconda 193
Donnybrook Lode 216
Doradilla C. Lode 216
Douglas Furnace 45
Drake 304, 311
Drake Division—
Adeline Mine 304
Bates' Lode 305
Border Chief Mine 305
Cullen's Creek 306
Drake District 307
Lady Mary Mine 309
Mount Carrington Mine 309
Pioneer Mine 310
Poor Man's Friend Mine 311
Rainbow Mine 311
Dripstone 290, 303
Dungowan 321, 328
Dyball's C. Mine 388
East Burraga Mine 142
,, Cobar Mine 216
,, ,, Freehold Mine 216
Eclipse C. Mine 98
Eldorado C. Mine 142
Elletson 226
Elrington 363
Emerald 217
Emmaville 305, 306, 308, 312
Emmaville Division—
Bald Nob Mine 305
Willows Mine 312
Emu Swamp 114
Endrick R. 336
Eskbank 401
Esmeralda C. Mine 142
Essington 136, 141, 143, 166
Ettrema Mine 345, 413
Eugowra 274
Eureka Mine 363
Euroa Mine 91
Eurow C. Mine 274
Europambella 321
Ewingar 187, 191, 192
Eyrie South Mine 177
Fairfield 305, 307
Fairy Hill 96, 99
Federal C. Mine 99, 345, 346
Fiery Creek 381
Fifield Division—
Mahgalore Lode 277
Mordialloc C. Mine 278
Fine Flour Mine 187
Firebricks 399–406
Fisher's C. Mine 321
Fittes Mine 302
Fitzroy Mine 143, 275
Flintoff's C. Lode 188
Florence Mine 99
Flux 260, 263, 298, 332
Foran's C. Mine 139
Forbes 274
Forest Reefs 169
Four-mile Lode 322
Fraser's Creek 328
Frogmore 345, 346, 351, 365–6
,, C. Mine 346
Frogmore Division—
,, C. Mine 346
Yundoo Lode 8

PAGE.

Frogmore Division—*continued.*
Pride of Frogmore Mine 365
Sapling Gully 366
Frog's Hollow 372
Fullback Mine 143
Galwadgery 235
Gaslight C. Mine 381, 396
Gegedzerick 378, 381
Gem Mine 139
George's Plains 140, 142
Geurie 300
Gilgunnia 217, 248
Gilgunnia Division—
Northumberland P.H. 217
May Day Mine 248
Gilmore Creek 395
,, Range 190
Gininderra 352
Girilambone 45, 217, 248, 400
Gladstone Mine 220
Glen Creek 312
Glencoe Mine 99
Glamorgan C. Mine 187, 139
Gobandry 269
Godfrey's Creek 272
Goobang 280
Good Hope C. Mine 352
Goodna Creek 353
Goodrich C. Mine 370
Goolma 226
Goondah 367
Goonumble Hill 220
Gordon 370
Gordon Brook 187, 190, 192
Goulburn 353, 364
Goulburn Division—
Bungonia 337
Chisholm's, Merrilla 338
Cullerin C. Mine 339
Curra Creek Mine 341
Jasper's Gully 354
Lucky Hit Mine 361
Merrilla 362
Mummell C. Mine 366
Sassafras 366
Talwong Mine 367
Grafton C. Mine 180
Grasmere Mine 100
Great Burril Mine 236
,, Central C. Mine 236
,, Cobar Mine 23–25, 36, 41–43, 45, 228, 246
,, Eastern Mine 247
,, Peak Mine 26
,, Southern S. Mine 269
,, Western Mine 143, 247
,, Wheal Burril Consols 220
Green Swamp Mine 144
,, Creek 336
Grenfell Division—
Arramagong 269
Boori C. Mine 271
Bumbaldry 271
Cowfell Mine 274
Grogan and Singleton's Mine 353
Growenbang 147
Gulf Creek 20, 322, 326, 328
Gulgandra 339
Gulgong 290, 291
Gulgong Division—
Belara C. Mine 286
Invicta G. and C. Mine 291
Gully Swamp 149
Gumble 145, 281
Gundagai 276
Gundagai Division—
Back Creek 270
Darbalara C. Lode 280
Gundagai 282
,, Mine 275
,, South 285
Jones' Creek 276
Mingary C. Lode 284
Reno 282
Snowball C. Mine 282

Digitized by Google

INDEX—*continued.*

PAGE.

Gunningbland 275, 280
Guy Fawkes 309
Guyong 141
Hall 382
Hall's Peak 330
Hampton C. Mine 100
Hannah's Bridge 289
Harrison's Mine 326
Hartwood 258
Hasting's Reef 263
Hawk's Nest Lode 146
Heathcote 62
Heffron's Creek 353
Hermidale 247
Hernani 309
Hilda May C. Lode 326
Hillgrove 330
Hillgrove Division—
  Styx River 311
  Ward's Mistake 311
  M'Kinley's Claim 311
  Sunnyside S. and C. Mine 330
Holmwood C. Mine 147
Honeybugle 291
Hopeful Mine 147
Hornsby Range 100
Hoy's Reef 326
Howe, H. M. 27
Hunter's Claim 248
Huntingdon Mines 263
Icely 143, 147, 158
Illunie Mts. 276
Infirtaris C. Mine 147
Ingalls, W. R. 60
Integrity Mine 148
Inverell Division—
  Mundowie C. Lode 328
Invicta G. and C. Mine 291
Invincible C. Mine 100
Iron 43
Ironbark's Lode 320
Ironclad Mine 273
Iron Duke Mine 127, 291
Ironstone Mine 299
Isbester's Paddock 290
Jackass Mine 148
Jacqua C. Mine 337
Jakoonbie C. Mine 187
Japan 57, 84
Jasper's Gully 354
Jasper Peak 264
Jenolan 116
Jindabyne C. Mine 382
Jocelyn Mine 148
John Bull Mine 148
Jones, C. H. 75
Jones' Creek 276
Jones' Lodes 189
Jones' Mine 148
Jounama Creek 391
Junee Division—
  Rockdale G. and C. Mine 283
Junee Reef 283
Just in Time Lode 190
Kahloe 193
Kaiser Mine 291
Kangaroo Mountain 383
Kangari 191
Kangiara 272, 354
Kapunda 63
Kelcshiel 149
Kempfield 149, 174
Kempsey Division—
  Long Flat 263
  Willi Willi C. Mine 265
Kenyu 350
Kiandra 375, 383
Kiandra Division—
  Blue Creek Reefs 375
  Coronation Mine 379
  Gaslight C. Mine 381
  Lobb's Hole C. Mine 384
  Yarrangobilly 396

PAGE.

Kiandra Division—*continued.*
  Castle Copper Lode 398
  Copper Mine Cave 398
Kimo 270, 275
Kindle 263
King of England Mine 276
Kookabookra 304
Kookabookra Division—
  Aberfoyle C. Lodes 304
  Guy Fawkes R. 309
Kooningbery Mountains 100
Koree 263, 265
Kosaka 85
Kupferschiefer 61, 74
Kyloe C. Mine 383
Lady Belmore Mine 149
  ,, Dorothy Mine 91, 99
  ,, Elwyn Mine 292
  ,, Hampton Mine 101
  ,, Lizzie Mine 372
  ,, Mary Mine 309, 327
Lake George Mines 26, 341, 354–360
  ,, Superior Mines 58, 79
Lal Lal 339, 340
Langford's Lease 280
Lang's Creek Mine 360
Larry's Hill C. Mine 163
Lead 44
Leadville 296
Leadville Division—
  Bowenbang Creek 289
  Denison Town 290
  Mount Laut 292
  ,, ,, South 293
  ,, ,, Dawson's 294
  Mount Scott 296
  Mount Stewart 296
Lewis Ponds 115, 149, 150, 159
Limestone 405
Lindberg's Mine 302
Little Mount Currumbla 280
  ,, Bell Mount 149
  ,, Copper Hill Mine 276
  ,, Gem Mine 150
Lloyd's C. Mine 80, 117
Lobb's Hole C. Mines 379, 384–387, 396
  ,, ,, Central 387
Locksley 150
London Bridge 391
Long Flat 263
Long Panel Lode 248
Low grade ore 24
Lowther 150, 179
Lucknow 175
Lucky Hit Mine 150, 175
Macanally G. and C. Mine 388
Mahgalore Lode 277
Major's Creek 361, 363, 368
Major's Creek Division—
  Mount Hope Mine 363
  United Miners 368
Malachite 18
Mallee Tank 210
Malongulli 110, 274
Mandourie Paddock 337
Mandurama 151
Mandurama Division—
  Mount Hope C. Mine 270
Manildra 145
Mann R. 192
Mannering's C. Mine 101
Mansfield 61, 74
Mary Bell Mine 96
May Day Mine 248
Mayfield C. Mine 362
May Queen Lode 190
M'Alpine C. Mine 388
M'Auley's Mine 307
M'Grath's C. Mine 96
M'Kinley's Claim 311
Melaconite 17
Melrose 269, 270, 277, 279, 283, 405
  ,, C. and S. Mine 277

Digitized by Google

INDEX—*continued.*

PAGE.

Merrilla ... 338, 361, 362
,, C. Mine ... 362-3
Merynia ... 247
Mickety Mulga ... 360
Middle Flat ... 377
Milburn Creek ... 20, 142
,, C. Mine ... 151, 155
Milparinka Division—
Kooningberry Mount ... 100
Milthorpe ... 161
Mines ... 10
,, abandoned ... 19
,, Water ... 15
Mingary C. Lode ... 288
,, Mount ... 305
,, South ... 290
Minnie C. Lode ... 191
Molong ... 138, 261, 274, 276, 278
Molong Division—
Armstrong C. Mine ... 269
Bell R. ... 270
Copper Hill C. Mine ... 138
Delaney's Dyke ... 274
Gumble ... 145
Little Copper Hill Mine ... 276
Molong Creek ... 278
Peabody C. Mine ... 281
Pine Hill C. Lode ... 281
Reedy Creek ... 282
Mona C. Loue ... 327
Monarch Elizabeth C. Mine ... 292
Monaro ... 374
,, C. Mine ... 388
Monmouth C. Mine ... 389
Montana ... 79
,, Ore Producing Co. ... 83
,, S. and C. Mine ... 155
Moondyke C. Mine ... 245
Moonta ... 14, 63, 64
Mootwingee C. Mine ... 101
Mookaie ... 94
Mount Bannaby C. Mine ... 363
,, Boppy C. Mine ... 248
,, Brown C. and G. Mine ... 191
,, Bulga C. Mine ... 157
,, Bullen ... 389
,, Burrawa ... 169
,, Carrington ... 307
,, ,, Mine ... 309
,, Costigan ... 158
,, Currumbla ... 280
,, Everest C. Mine ... 327
,, Felstead C. and S. Mine ... 278
,, Fiery C. Lode ... 296
,, Fisher C. Lode ... 388
,, Fraser C. Mine ... 159
,, Hope ... 226, 292, 400
,, ,, C. Mine ... 250, 388
Mount Hope Division—
Great Central Cobar Mine ... 226
Mount Hope C. Mine ... 250
Mount Hornsby ... 95
,, Jasper C. Mine ... 284
,, ,, Peak Lode ... 285
,, Keenan ... 279, 292
,, Kenyu ... 351
,, Lauff C. Mine ... 327
,, Laut ... 292
,, ,, South ... 293
,, Lindsay C. Mine ... 158, 191
,, Lyell ... 15, 27, 70
,, McDonald ... 159
Mount McDonald Division—
Cowra District ... 141
Eldorado C. Mine ... 142
John Bull Mine ... 148
Milburn Creek C. Mine ... 151
Silver City Lode ... 159
Mount Mingary C. Lode ... 289
,, Morgan ... 14, 66
,, Morris ... 149
,, ,, C. Mine ... 159
,, Nobby ... 278
,, Nome ... 159

PAGE.

Mount Parnassus ... 362
,, Pleasant C. Mine ... 254, 258, 328
,, Ragan ... 150, 159
,, Rose ... 372
,, Royal C. Mine ... 294
,, Scott ... 298
,, Shorter ... 169
,, Stewart Mine ... 296
,, Susannah C. Lode ... 279
,, Trooper ... 300
,, View ... 265
,, Warning ... 191
Mountain Maid Lode ... 155
,, Rum Mine ... 155
Mordialloc C. Mine ... 278
Moruya S. Mine ... 58
Mudgee Division—
Wilbetree ... 303
Mugin Wybra Creek ... 189, 190, 192, 193
Mulga Springs ... 94
Mulloon C. Mine ... 336, 364
Mullumbimby ... 191
Mundowie C. Lode ... 358
Mummell C. Mine ... 364
Murchison Lode ... 329
Murga ... 280, 283
Murrumbidgee C. Lode ... 265
Nadbuck C. Mine ... 161
Namoi C. Mine ... 324
Nangar Range ... 240
Nangeribone ... 250
Narraba Creek ... 306
Narrabeen ... 62
Narradin ... 96
Narri ... 259
Native Bee Mine ... 299
Neila Creek ... 240
Nerriga ... 367
Nevada S. and C. Mine ... 160
New Babinda ... 216
Newbridge ... 160, 167
New Burra Burra C. Mine ... 248
Newton Boyd S. and C. Lode ... 192
Nickel ... 43
Nil Desperandum Lode ... 192
Nine-Mile Claim ... 91
Nithholm ... 300
Nobby's Mine ... 176
Nogrigar C. Lode ... 192
North Buckinbar ... 373
,, Essington Mine ... 160
,, Nymagee C. Mine ... 254
,, Shango ... 197
Northumble ... 217
Newendoc ... 320
Nowra Division—
Bundundah ... 337
Ettrema Lode ... 345
Touga C. Mine ... 367
Nundle Division—
Bowling Alley Pt. ... 313
Bungowan ... 321
Fisher's C. Mine ... 321
Mount Pleasant Mine ... 328
Nuntherungie C. Mine ... 101
Nymagee ... 25, 254, 255, 257, 405
Nymagee Division—
Cobar Lyell Mine ... 211
Crowl Creek Mine ... 211
,, ,, S. C. Mine ... 215
Day Bros.' Mine ... 226
Donnybrook Lode ... 216
Girilambone C. Mine ... 211
Great Western Mine ... 247
Hunter's Claim ... 248
Moondyke C. Mine ... 248
Nangeribone ... 250
North Nymagee C. Mine ... 254
Nymagee C. Mine ... 255
Star of the West Mine ... 261
Wirlong ... 261
Nyngan Division—
Wilgarbone ... 262

Digitized by Google

INDEX—*continued.*

PAGE.

Oberon 139
Oberon Division—
Bull's Creek 116
Copper Hill 139
Louther 150
Tarana 174
Tuglow 174
Yates' Tarana 179
Occidental G. Mine 258
O'D. Mine 161
Ophir C. Mine 161
Orange ,, ... 114, 157, 158
Orange Division—
Bob's Mt. 114
Britannia Mine 115
Byng 126
Cadia C. Mine 127
,, Extended C. Mine 132
Canoblas 133
Carangara C. Mine 134
Hawk's Nest Lode 146
Icely Mine 147
Lady Belmore Mine 149
Little Bell Mt. 149
Mt. Fraser C. Mine 158
Mt. Lindsay C. Mine 158
Mt. Ragan 159
O'D. Mine 161
Ophir C. Mine 161
Pride of the Hill Mine 166
Rat's Castle Lode 166
Slattery's Creek 169
Wallaby Rocks 175
Wellwood 175
Orange Plains 292
,, ,, C. Mine 299
Ores 17
Orient Mine 102
Overflow Mine 194, 261
Packsaddle 700
Panton 265
Paragon Lode 102
Parkes 275, 280
Parkes Division—
Gunningbland C. Lode 275
Parrott Smelting Works 83
Payne's Mine 271
Payten's Mine 274
Peabody C. Mine 281
Peak, Coonia 391
Peak Downs 66
Peak Hill G. Mine 299
Peelwood C. Mine 161
Perth 106
Peters, E. D. 70, 81
Pether's Lode 391
Phœnix C. Mine 163, 281, 341
Phosphorus 44
Picton Division—
Bullio 336
Pine Hill C. Lode 281
Pine Ridge 290
Pinnacles 310
Pioneer Mine 310
Pluck Mine 192
Pokolbin 265
Ponto Mine 103
Poor Man's Friend 311
Port Macquarie 265
Port Macquarie Division—
Huntingdon Mines 263
Kindie 263
Mount Jasper C. Mine 264
,, Peak Lode 265
Port Macquarie 265
Rose Hill Mine 265
Portugal 58
Potato '. Lode 198
Pride of Frogmore 305
,, the Hills Mine 166
Prince of Wales C. Mine 329
Princess Midas Mine 91
Production—Australian 86, 87

PAGE.

Production—World 88
Prosper Mine 166
Pucka 180, 190, 192
Pulganbar 188, 189, 192
Purnamoota 91, 93, 103
Pye's Creek 311
Pyritic Smelting 26-28
Queanbeyan Division—
Balconnel G. Mine 374
Congwarra C. Lode 377
Cowley C. Lode 379
Hall 382
Mount Bullen 389
Queanbeyan 391
Queen Bee 259
Queen of England Claim 276
,, the Stream Mine 300
Queensland 66
Quidong 9, 374
Quigley's Hill C. Mine 166
Rainbow Mine 307, 311
Ramping Lion Lode 282
Ranger's Mine 168
Rat's Castle Lode 166
Recovery C. Mine 261
Red Flag C. Mine 103
Red Hill 382, 391
Red Hill Mine 166, 366
Reedy Creek 271, 282
Refining 86
Refractory ores 41
Reno 282
Rifle Butt Claim 282
Rigby's Reef 361
Right Hand Creek 351
Rio Tinto 15, 20, 75
Rise and Shine Mine 167
Rivertree 306
Rockdale G. and C. Mine 283
Rockley 6, 115, 147, 150, 167, 168
Rockley Division—
Balmoral C. Mine 109
Belmore C. Mine 100
Black Mountain Mine 110
Brown's Creek 115
Cash-Essington Mine 136
Cow Flat C. Mine 140
,, District 141
Dolcoath Mine 141
Essington 143
Fitzroy Mine 143
Fullback Mine 143
Integrity Mine 143
Jackass Mine 148
Jocelyn Mine 148
Lucky Hit Mine 150
Mountain Run 155
Sugarloaf Mine 156
Mount Bulga C. Mine 157
North Esington Mine 160
Phœnix C. Mine 163
Larry's Hill C. Mine 163
Prosper Mine 166
Rockley District 167
Ranger's Mine 168
Shepherd's Mine 168
South Wiseman's Creek C. Mine 169
Summer Hill C. Mine 171
Wiseman's Creek C. Mine 177
Rockwall Paddock 90, 103
Rosebank Mine 392
Rosedale 158, 166
Rose Hill C. Mine 265, 300
Rose Valley 381, 391
Royal George Mine 329
,, Sweep Mine 288
Ruby C. Mine 103
Running Stream 300
Rye Park 362
Rylstone 300
Sandy Creek 326
Sapling Gully 366
,, Point Creek 366
Sassafras 366

Digitized by Google

INDEX—*continued.*

	PAGE.
Sawpit Gully	308
Shango Mine	197
Shepherd's	168, 281
Shoalhaven River	337, 366–7
Shuttleton C. Mine	211
Silica	44
Silver City Lode	169
Silverton	90, 91, 102, 104
Singleton Division	265
Slattery's Creek	169
Smelting	27
Snob's Mine	363
Snowball C. Mine	390, 392
,, Hill	392
Snowy River	394
Sofala	373
Sonoma	337
South Australia	63
,, Budgery	261
,, Mount Boppy	261
,, Queen Bee	261
,, Wiseman's Creek C. Mine	169
Spain	58, 75
Spion Kop	367
Sprague's Mine	169
Spring Creek	278, 329
,, C. Mine	329
Star of the West	261
Stuart Town Division—	
Al Mine	369
Cheshire C. Mine	369
Cyclops C. Mine	369
Dolcoath Lode	370
Goodrich C. Mine	370
Lady Lizzie Mine	372
Mount Rose	372
N. Buckinbar	373
Tinby Hill	373
Viles' Lode	373
Yeoval	373
Styx River	311
Sugarloaf	170, 285
,, C. Mine	155, 170
Sultan C. and L. Mine	283
Summer's C. Mine	170
Summerhill	6, 7, 8
,, C. Mine	171
Sunny Corner	43, 155, 160, 172
Sunny Corner Division—	
Nevada S. and C. Mine	160
Sunnyside C. and S. Mine	330
Sweet Nell Lode	331
Sydney-Wallaroo C. Mine	300
Talbragar	296
Tabratong	291, 292
Tabulam	187
Talbingo	391
Talwong Mine	367, 413
Tamworth	331
Tamworth Division—	
Attunga C. Mine	313
Namoi C. Mine	328
Trough Gully N. Mine	331
Tara	93
Tarago	341
Taralga	363
Taralga Division—	
Mount Bannaby C. Mine	363
Tarana	174, 179
Tarella Consols Mine	101
Tasmania	70
Tin	43
Tinby	369
Tinby Hill	373
Tindary	210
Tingha	329
Tingha Division—	
Conrad Stannite Mines	320
Cope's Creek	320
Hoy's Reef	326
Lady Mary Mine	327
Royal George Mine	329
Thackaringa	97
Thames Gully	335

	PAGE
Tharsis C. Co.	24, 75
Thompson's Creek	19
Top Bingara	287
Top Tank	291
Touga C. Mine	367
Trinidad C. Mine	104
Trough Gully N. Mine	331
Trundle	278, 281
Trunkey	174
Tuena	140, 161
Tuena Division—	
Cordillera Hill	140
Mount Costigan	178
Peelwood C. Mine	161
Tuglow	174
Tumut	376, 381, 382, 395, 396
Tumut Division—	
Adjungbilly Creek	374
Bogong C. Mine	358
Brungle	377
Kangaroo Mountain	381
McAlpine C. Mine	382
Mingary	385
Pether's Lode	391
Talbingo	391
Red Hill C. Mine	392
Wyangle	396
T. W. Copper Lode	25
Ulladulla Division—	
Conjola Creek	35
Umberumberka	97
Umeralla	292
United Empire Mine	123
United Miners	264
United States	79
Upper Bingera	281
Uriara	291
Victory Lode	282
Viles'	373
Vychan C. Mine	123
Wadsworth, M. E.	77
Wagara	77
Walcha	321, 322
Walcha Division—	
Cooperacurripa C. Mine	89
Europambella Lode	321
Walker's Hill	194, 211
,, Pinch Lode	196
Wallah Wallah	296
Wallaby Rocks	177
Wallaroo	42, 63
,, Lode	193
Wambrook	296
Waratah	407
Ward's Mistake	311
Ware	172
Warialda	182
Washoe	43
Wauchope	263
Waugoola Creek C. Mine	177
Waukéroo	367
Weandre Creek	322
Weed, W. H.	59, 74
Welcome Reef	97
Wellington	344
,, Champion Hill Lode	344
Wellington Division—	
Backe's C. Mine	345
Bungiebomar	347
Dripstone	347
Great Wheal Burril C. Mine	348
Kaiser Mine	347
Rose Hill C. Mine	350
Wellington District	347
Yarragol C. Mine	350
Wellwood	177
Wertago	92, 93, 96–98, 101
,, C. Mine	104
West Bogan	13
West Hill Lode	175
Wet Creek	319
White Cliffs Division—	
Big Wertago Mine	92
Brady's Proprietary Mine	93

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INDEX—*continued.*

	PAGE.
White Cliffs Division—*continued.*	
Broken Hill Mine	96
Copperwell Mine	97
Eclipse C. Mine	98
Grassmere Mine	100
Nuntherungie C. Mine	101
Wertago C. Mine	104
Wilbetree	303
Wiley's Lode	198
Wilgarbone	226, 247, 262
Willi Willi	265
Willie Ploma	392
Willow's Mine	312
Wilmatha Tank	277
Wilpina C. Lode	333
Wirlong	261
Wiseman's Creek	139, 148, 169, 177
,, C. Mine	177–179
Wollondilly Valley	336
Wonaminta	100
Wood's Reef	326, 329, 333, 334
Woodstock	116, 175–76, 270
Woolgarlo Mine	368
Wrightville	226
Wyangle	382, 396
Yarragol	303
Yarrakalkiarra	187
Yarrangobilly	379, 396, 398
Yass	8, 353, 366, 368
Yass Division—	
Good Hope C. Mine	352
Kangiara Mine	354
Red Hill Mine	366
Sapling Point Creek	366
Woolgarlo Mine	368
Yates' Tarana Mine	179
Yellow Mount	248, 262
Yeoval	369–373
Yetholme	144, 269
Yorkey's Creek	179
Yulgilbar	198
Yundoo Lode	352
Zinc	41

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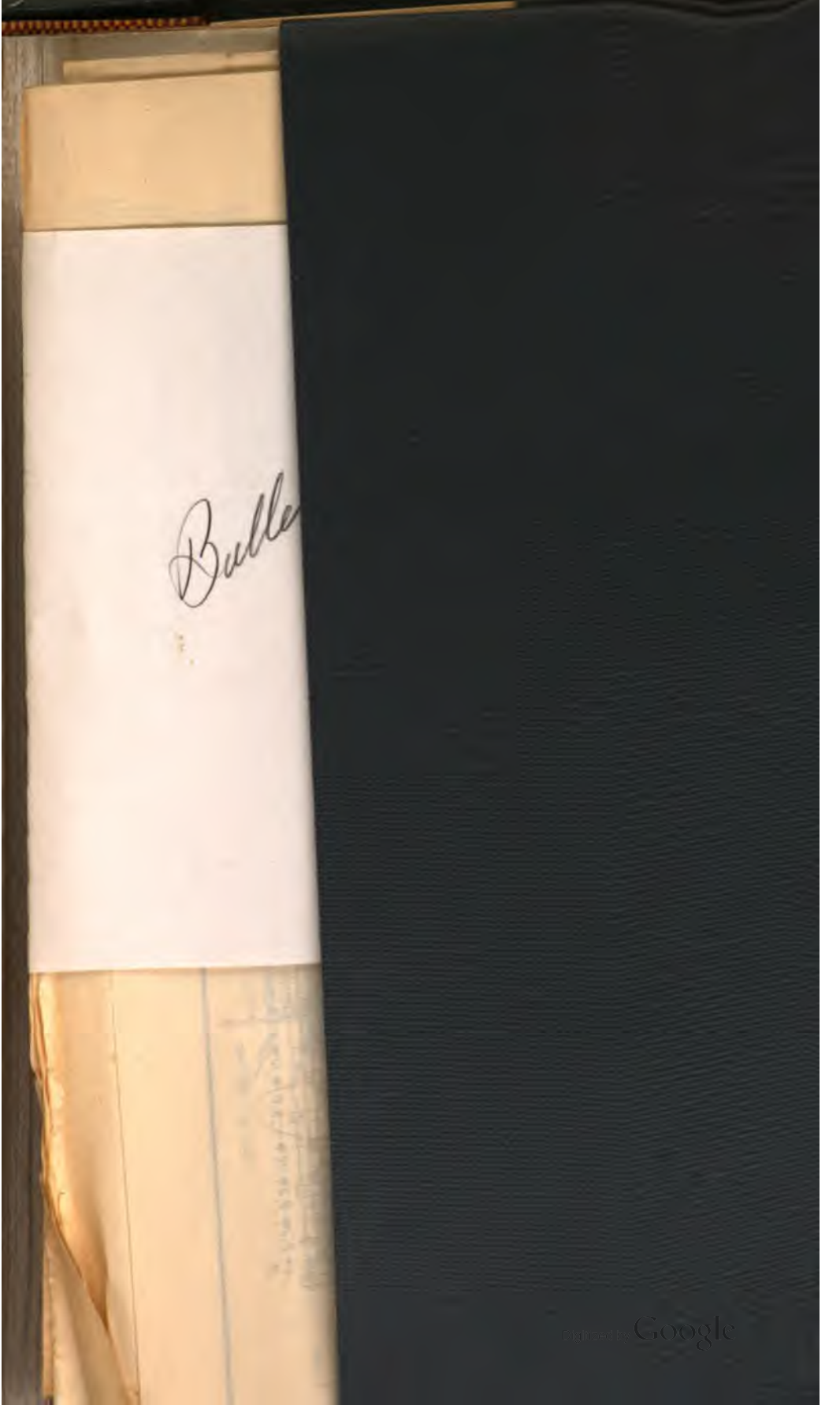

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NEW SOUTH WALES.

DEPARTMENT OF MINES AND AGRICULTURE.

GEOLOGICAL SURVEY.

E. F. PITTMAN, A.R.S.M., Government Geologist.

MINERAL RESOURCES.

No 7.

MERCURY, OR "QUICKSILVER,"

IN

NEW SOUTH WALES,

WITH

Notes on its Occurrence in other Colonies and Countries.

BY

J. E. CARNE, F.G.S.,

GEOLOGICAL SURVEYOR.

1900.

SYDNEY: WILLIAM APPLEGATE GULLICK, GOVERNMENT PRINTER.

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Geological Survey Branch,
Department of Mines and Agriculture,
2 May, 1900.

Sir,

I have the honor to transmit for publication, Report No. 7 of the Mineral Resources Series, on "Mercury, or Quicksilver, in New South Wales, with Notes on its occurrence in other Colonies and Countries," by Mr. J. E. Carne, F.G.S., Geological Surveyor.

Ores of mercury have not hitherto been profitably worked in New South Wales, although deposits of cinnabar have for some years been known to exist in several districts. In view of the very large quantity of mercury which is annually used in this Colony in connection with the gold-mining industry, it would be a very great advantage if the metal could be produced locally. It is therefore of importance that careful descriptions of the known deposits of cinnabar should be published by the Department, and it is to be hoped that where the attention of mining men has been thus directed to the subject, efforts will be made, not only to work the deposits which are already known to exist, but also to prospect for the mineral in other localities.

I have the honor to be,
Sir,
Your obedient servant,
EDWARD F. PITTMAN,
Government Geologist.

The Under Secretary for Mines.

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TABLE OF CONTENTS.

	PAGE
Introduction	3
Mercury: Its Characters, Ores, Uses, and Value	5
Principal Sources of Supply: Modes of Occurrence, Geological and Mineralogical Associations	6
Average Working Yields from some of the Principal Mines	7
World's Output of Mercury in 1898	8
Notes on Metallurgical Treatment	8
Index of Mineral Localities in New South Wales	10
Historical and Descriptive Record of New South Wales Deposits	11
Queensland Deposits	31
Victorian ,,	32
New Zealand ,,	33

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INTRODUCTION.

Prior to the practical application of the valuable amalgamating property of mercury in silver metallurgy by a Mexican miner in 1557, the use of the metal, though of ancient date, was restricted chiefly to the very limited demands of the fine arts; the brilliant pigment "vermilion" being prepared from the natural or artificially produced sulphide of mercury.

The Mexican discovery rapidly augmented the demand for quicksilver for the extraction of silver from its ores, and correspondingly increased its output. The extension of amalgamation to gold-mining and milling at a comparatively recent date, however, gave the principal impetus to the industry, and has governed all subsequent demand and supply.

The powerful affinity of mercury or quicksilver for gold, and the ease and efficiency of its application as a collector and saver, render it practically indispensable to the gold-mining industry. Its usefulness and comparative rarity—for mercury occurs in relatively few places in workable quantities—maintain for it continuous demand and value, though the reported control of a powerful combine or "ring" may, and probably does, frequently unduly influence the latter. Demand and supply, therefore, may not always balance fairly at ruling market rates, which are subject to considerable fluctuation.

The capricious occurrence and comparative poverty of mercury ores, combined with cost and loss in reduction, in the majority of instances narrow the margin of profit to extremely fine lines. Becker, in 1888, estimated the cost of production at 90 per cent. of the average price.*

Hence in this, as in all other metalliferous mining, the lowest grade deposits demand the maximum of knowledge and experience. Rich deposits can sustain experimental or undue working loss, the avoidance of which in treatment of lower grades represents the only possible margin of profit.

It is imperative, therefore, that the possible inception of the mercury industry in Australasia should be safeguarded in this direction. Haphazard methods of management must give way to wiser counsels in the institution of an entirely new and difficult enterprise in these regions.

In the early days of gold discovery in California and Australia, the sudden excessive demands for quicksilver, operating on a slender market, forced values to an abnormal height (over £23 per flask of 76½ lb. being realised according to Egleston),† which decreased gradually in direct ratio with

* Geol. of Quicksilver Deposits of the Pacific Slope. U.S. Geol. Survey, Mon. xiii, 1888, p. 1.

† Metallurgy of Silver, Antimony, and Mercury in the United States, 1890; by T. Egleston, vol. ii, p. 799.

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increasing supply and waning gold production until £9 per flask was reached in 1866. In 1870 a sudden rise to £29 per flask took place, according to the same authority; after which it fell steadily to about £5 per flask in 1883, since when it has fluctuated between £5 10s. and £9 12s. 6d. per flask, the latter being the rate now ruling. †

The present average market value appears likely to be maintained unless phenomenal discoveries ensue, for, notwithstanding the rapid advance in metallurgical and electro-metallurgical science, no substitute or process is foreshadowed to completely contest the monopoly of this valuable mobile metal, or dispute its economic utility and efficiency as a gold saver when the precious metal is in a condition open to attack.

Chlorination and cyanidation gold-recovery processes are independent of mercury in their especial spheres; yet these, from their comparatively limited application, are subordinate and subsidiary to ordinary amalgamation.

The cost of chlorination restricts it with rare exceptions, such as Mount Morgan in Queensland, to treatment of concentrates after amalgamation, in which gold is mechanically cloaked by sulphides of baser metals. Extraordinary fineness and a filmy coating of iron oxide prevented perfect contact with the Mount Morgan gold.

Cyanidation is almost equally as rigidly confined to tailings—or exceptional ores—containing gold in so fine a state of division as to render specific gravity inoperative and contact impossible during water transport over amalgam plates.

The importance, therefore, of workable deposits of mercury in a gold-producing country cannot be easily over-estimated. Unfortunately, Australasia has not yet been able to add it to her list of profitable mineral products, though in New South Wales, Victoria, Queensland, and New Zealand the principal and only workable ore, the sulphide cinnabar and its varieties, has been found in more or less hopeful quantities (associated, in some instances, with the native metal), from which small quantities of mercury have been locally retorted.*

The present number of "Mineral Resources" is a statement of the occurrence of mercury in New South Wales, and the progress of its mining developments to date, supplemented by notes on discoveries in the neighbouring Colonies, and on the principal sources of the World's supply, the object being to stimulate interest and promote research, in the hope of further and more important discoveries within Australasian territories.

* Mr. R. M. Johnston, F.L.S., in the Tasmanian Official Record, 1892, p. 126, mentions the selenite of mercury (*Onofrite*), but the locality is not given. In the same work for 1893, p. 10, the occurrence of mercury with other ores in Silurian rocks is recorded. The locality is, however, again omitted.

† Mining Journal, 1900, lxx, No. 3366, p. 227.

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MERCURY, OR "QUICKSILVER."

Physical Characteristics.

A SILVER-WHITE lustrous metal, fluid at ordinary temperature. Specific gravity 13·59 (Regnault). Solidifies at about 39 to 40° C. Vapourises at 360° C. Vapour density, 6·7 to 7·03. For complete volatilization, a low red heat 500 to 600° C. is required (Schnabel and Louis).

Alloys of Mercury.

Mercury amalgamates readily with gold, silver, zinc, tin, cadmium, lead, and bismuth; with copper easily when finely divided, but with difficulty in the massive state; arsenic, antimony, and platinum amalgamate with difficulty; iron, nickel, and cobalt not at all directly.*

Chief Uses.

Amalgamation of gold and silver; preparation of vermilion; in medicine; barometers, thermometers, mirrors, &c.

The great density of mercury, and its regular expansion and contraction by increase or diminution of temperature, render it most suitable for filling barometers and thermometer tubes.

Ores of Mercury.

Cinnabar (HgS)—Mercury Sulphide. Specific gravity, 8·99; hardness, 2 to 2·5; contains 86·2 per cent. of mercury. The most important ore of mercury.

Varieties.

Metacinnabarite.—Black variety, non-crystalline. Lower specific gravity than cinnabar.

Hepatic Cinnabar.—Cinnabar mixed with bituminous matter, which gives it a red to black colour.

A mixture of cinnabar with idrialite (C_3H_2), occurs at Idria.

Coralline Ore.—A mixture of cinnabar, bituminous matters, and about 60 per cent. of calcium phosphate.

Ammiolite.—An earthy powder, colour deep red, regarded as an antimonate of copper mixed with cinnabar.

Onofrite.—A sulpho-selenite of mercury occurring at San Onofre, in Mexico.

Tiemannite.—Mercuric selenide.

Coccinite.—Iodide of mercury; Mexico.

Livingstonite.—A sulphide of antimony containing mercury.

Mercurial Fahlore, or *Tetrahedrite*, sometimes contains up to 18 per cent. of mercury (Schnabel and Louis).

Zinc-blende occasionally contains small quantities of mercury.

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* Handbook of Metallurgy, Schnabel and Louis, 1896, ii, p. 254.

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Principal Sources of Supply.

Europe and America.

The most important mercury deposits in Europe are Almaden in Spain Idria in Carniola (Austria-Hungary), and Nikitowka in Southern Russia.

The following brief descriptive notes are extracted from the Handbook of Metallurgy*:—

"At Almaden, cinnabar occurs with native mercury in an area 10 miles by 6 miles in Silurian and Devonian strata, consisting of slates, quartzites, sandstones, and small quantities of limestone, forming three almost tabular deposits about 600 feet in length, and 12 to 25 feet wide. In these the mercury ore occurs both in masses and disseminated. The grade varies from 0·75 to 25 per cent., and is said to average about 8 or 9 per cent.

"These deposits were known as early as 300 B.C., and still remain the most important in Europe."

According to Becker† they are reported to increase in richness with depth.

The Idrian deposits occur partly in the nature of a stockwork, and partly as contact veins between dolomite and limestone of Triassic age. The ore averages from 0·5 to 0·8 per cent. These deposits were known in 1490, and rank next in importance to those of Almaden, and like them are reported also to increase in richness with depth. (Schnabel and Louis, *ibid*, p. 258.)

At Nikitowka, in Southern Russia, cinnabar occurs impregnating sandstone of Carboniferous age, having a thickness of 46 feet. The average grade is stated to be 0·6 per cent. These deposits rank next in importance to those of Almaden and Idria in Europe.

The most important mercury deposits in North America—the New Almaden, New Idria, Napa Consolidated, Etna Consolidated, Altoona, and Great Eastern, —occur in California. At one time their output exceeded that of Almaden in Spain, but, unlike the latter, the deposits decreased in value with depth.

The North American mercury deposits are stated by Schnabel and Louis to occur in a "zone of slates of the Cretaceous and Tertiary periods, consisting of talcose, micaceous, clay and siliceous slates, serpentines, sandstones, limestones, and dolomites, penetrated by numerous outbursts."

"This zone of slates is more or less strongly impregnated with cinnabar in various places, at some of which, especially where serpentine and sandstone are in contact, the proportion of mercury is a very high one, amounting to as much as 35 per cent. The ore occurs both as contact deposits and also disseminated in serpentine and sandstone. At various places the cinnabar is accompanied by pyrites and bituminous substances; at others it occurs impregnating chalcedony, which may then contain as much as 3 to 10 per cent. of mercury."

The deposits at Sulphur Bank in California, and Steamboat Springs in Nevada, are especially interesting on account of their association with still active geyser action. Cinnabar here accompanies sulphur, which at Sulphur Bank was first mined. The average grade is reported as 1·75 per cent. of mercury.

Becker states‡ that "rocks enclosing quicksilver deposits are of very diverse ages, ranging all the way from Archæan granites and schists to recent strata and lavas. The lithological variety of the enclosing rocks is equally great, including limestones, sandstones, and shales, many kinds of metamorphic strata, and massive rocks of acid, neutral, and basic types."

---

* Schnabel and Louis, 1893, ii, pp. 256, 257.
† Geology of the Quicksilver Deposits of the Pacific Slope. U.S. Geol. Survey, Mon. xiii, 1888, p. 4.
‡ *Ibid.*, 452.

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He further states that quicksilver deposits occur along the great axes of disturbance of the world; also that cinnabar occurs in "true, simple, fissures and veins, in impregnations, and stockworks"*

"The facts recorded point to the supposition that most of the quicksilver deposits, if not all of them, have been formed in a similar manner. They have all been deposited from solution, for the gangue minerals could have been formed in no other way.

"The gangue minerals are few in number and substantially the same in all deposits." . . . "They are crystalline silica, opal, calcite, and dolomite."

Cinnabar is being deposited from thermal springs at high temperatures at Pozzuoli, in Italy, Steamboat Springs, Nevada, and Lake Omaphere, New Zealand, and there is reason for believing that similar conditions prevailed in all deposits.

R. B. Symington, writing of the Californian deposits, states:—"Generally the veins are mineralizations, along faults occurring near the contact of metamorphic and unaltered rock. A variety of serpentine, locally called 'quicksilver rock' is the usual metamorphic rock; while sandstone and shale constitute the unaltered strata."

"Occasionally the ferruginous shales are interlaminated with bands of jasper which often has a bold outcrop, and, looking like cinnabar, is sometimes mistaken for the latter, but the real veins seldom show a bold outcrop." [Large boulders of red jasper in the Cudgegong cinnabar drift have been similarly mistaken.—J.E.C.]

"When a porous rock like sandstone forms the wall of a vein, it is often impregnated with cinnabar for a considerable distance from the fissure, and the true vein matter may be comparatively barren; but if clay, or any impervious rock, forms the wall, no ore will be found beyond that line."‡ The writer recommended crosscutting in consequence of the above features. He further stated that formerly it was the custom to search only for higher grade ore; now everything over 0·5 per cent., or ½ per cent., is worked. More than once the waste dumps have been turned over with profit.

AVERAGE WORKING YIELDS OF SOME OF THE PRINCIPAL MERCURY MINES.

	Mine.	Tons of Ore smelted.	Average Yield.	Flasks of Mercury Produced in 1898.	Receipt per Flask.	Cost per Flask.	Remarks.
			%		$	$	
California.	Napa Consolidated	32,489	0·8	6,850	35·89	21·33	Total production of United States in 1898 = 80,493 flasks.
	New Idria	18,627	1·03	5,000	35·86	17·48	
	Etna Consolidated	18,394	0·72	3,450	36·03	26·55	
	New Almaden ..	....	....	5,875	....	....	Worked to a depth of over 2,000 ft.
	Altoona	....	....	4,032	....	....	
	Great Eastern ..	....	....	1,704	....	....	
	Redington	....	....	990	....	....	
	Almaden, Spain ..	....	8·0	46,211*	....	....	* Produced in 1898.
	Idria, Austria ..	....	0·8	.....	....	....	
	Nikitocka, Russia†	....	1·0	10,104*	....	....	* 22,122 poods in 1898.
Italy	Siele ..	....	1·2	.....	....	....	Average metallic contents of ores smelted at these mines, according to Vincente Spirek (*Mineral Industry*, vi, 1897, p. 568); an increasing proportion of low-grade ores is being worked in Italy.
	Cornacchino	....	0·6	.....	....	....	
	Montebuona	....	0·4	.....	....	....	
	California, U.S. ..	....	1·3	.....	....	....	

* *Op. cit.*, pp. 388, 453.
‡ Mineral Industry, 1898, vii, p. 532.
† Russian yields (*Mineral Industry*, vi, p. 567)—1887, 1 per cent.; 1888, 0·76 per cent.; 1889, 0·51 per cent.; 1890, 0·73 per cent.; 1891, 0·8 per cent.; 1892, 0·65 per cent.; 1893, 0·46 per cent.; 1894, 0·46 per cent.; 1895, 0·69 per cent.; 1896, 0·71 per cent.; 1897, 0·79 per cent.

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World's Output of Mercury, 1898.

Spain	1,681	metric tons.
United States	1,058	,,
Austria	494	,,
Russia	362	,,
Mexico	353	,,
Italy	170	,,
Total	4,118	,,

Notes on the Metallurgy of Quicksilver.

C. Schnabel* states that two methods are used upon a large scale for the extraction of mercury—"the one depends upon the fact that at a high temperature the oxygen of the air combines with the sulphur of the mercuric sulphide, forming sulphur dioxide, whilst the mercury is set free," according to the following equation:—

$$(1)\quad HgS + 2O = Hg + SO_2.$$

The other depends upon heating the mercuric sulphide with lime when the sulphur combines with the calcium, forming calcium sulphide and sulphate, whilst the mercury is liberated:—

$$(2)\quad 4HgS + CaO = 4Hg + 3CaS + CaSO_4.$$

Instead of lime iron may be employed—

$$HgS + Fe = FeS + Hg.$$

In every case the above chemical reactions take place at temperatures higher than the boiling point of mercury; so that the latter is separated in the gaseous form, and has to be condensed.

"The first process is effected by heating cinnabar in the air; the second by heating with lime or iron, air being excluded.

"The mercury vapours in the first method are diluted with sulphur dioxide, nitrogen, and oxygen, and with the products of combustion if shaft or reverberatory furnaces be used."

In the second method the mercury vapours are in a concentrated condition.

The extraction of mercury by heating in air is regarded by authorities as the most suitable for economic and hygenic reasons. It may be carried out either in shaft, reverberatory, or muffle furnaces. When the two former are used, large quantities of ore can be treated with comparatively small consumption of fuel and labour. The process, however, is open to the objection already stated, of contamination of the mercury vapours with other elements, which interfere with condensation and occasion loss.

The extraction of mercury by heating with lime or iron must be performed in retorts. This process, however, requires the ore to be crushed, only small quantities can be treated, retorts last a comparatively short time, costs of fuel and labour are high, and workmen are affected by the fumes when the retorts

* Handbuch der Metallhüttenkunde. Eng. Trans. by H. Louis, 1896, ii, pp. 260, 261.

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are emptied out; altogether unsuitable for poor ores on account of cost. The latter can only be treated on a large scale, for which furnaces and continuous roasters are alone adopted, according to Vincente Spirek * the inventor of one of the most successful improved furnaces.

According to Schnabel and Louis † the losses in the best furnaces and methods have been reduced from 50 to about 6 or 8 per cent of the amount of mercury in the ore.

Writing on the "Quicksilver Industry of Italy," Vincente Spirek ‡ states:—"In the metallurgy of quicksilver, one of the first principles is to adapt the furnace to the mine ore, and never attempt to adapt the latter to the furnace by means of wet concentration. It is when poor ores have to be treated that the greatest knowledge and experience in the selection of a proper furnace are required".

"The separation of the ore into grades of varying richness usually takes place in the mine itself, single rich pieces being won by spalling from the ordinary ore. The poorer ores are generally divided by screening into two classes—'coarse ore' of 35 mm. diameter, and 'fine ore', of less than 35 mm. diameter. The coarse ore is worked either by direct treatment in shaft furnaces by means of coke, coal, lignite, peat, or wood, or in so-called shaft reverberatories by means of gaseous fuel, produced in separate generators. The fine ore, which is sometimes again subdivided into medium, coarse, and fine, is worked in reverberatories *(Fortschauflungsofen)*, or continuous roasters *(Schüttofen)*. The rich ores are mixed with lime or iron, and treated by sublimation, either in continuous roasters or in muffle furnaces. The actual operations are therefore divided into the roasting method and the sublimation method.

"At the present time nearly all the works employ the roasting method, which consists in decomposing the cinnabar by means of an oxidation of its sulphur through the agency of atmospheric oxygen, and subsequent volatilization of the metallic quicksilver. It is thus evident that the theoretical extraction of the metal is a very simple one. In practical work, however, this is not found to be the case. The greatest practical difficulties encountered lie first in the excessive volatility of the metal, and secondly in its high specific gravity as a fluid, which greatly facilitates its penetration into the ground and into all the foundations, and lastly in a property which has so far received but little attention, and works exactly in an opposite direction to gravity, namely, the sickening of the quicksilver *(Quecksilberschaumbildung)* by fatty substances, which prevent the smallest metallic spheres from coalescing, and hold them as a fine film on the surface of the water, with which they are carried off, thus causing considerable losses."

As an instance of the leakage or penetration of mercury, Egleston § states that at the New Almaden Mine, in California, in 1863, 2,000 flasks (153,000 lb.) were taken from the ground under and near one of the furnaces, the mercury having penetrated 27 feet to bedrock.‖

Cinnabar mining is not in itself harmful, providing native mercury is not present in quantity. The precautionary measures advised against mercury poisoning in mining and smelting are cleanliness, open air, acid foods, and moderation in the use of alcohol.

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* Mineral Industry, 1897, vi, p. 569. † Handbook of Metallurgy, 1898, ii, p. 263.

‡ Min. Industry, 1897, vi, p. 569. § Metallurgy of Silver, Gold, and Mercury in U.S., ii, p. 814.

‖ A considerable leakage is reported to have taken place in connection with the limited smelting operations at the Ohaeawai Mines, New Zealand.

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Mercury Localities in New South Wales.

Locality.	County.	Geological Formation.	Reference.	Page.
Bingara, Spring Creek, near	Murchison ..	Serpentine and clay slate.	T. W. E. David, Ann. Rep. Dept. Mines N. S. Wales for 1891, p. 234.	
Boorook, Clifton Silver Mine	Buller	Clay stone	Liversidge, Minerals of N. S. Wales, 1888, p. 52.....	
Broken Hill, Broken Hill Lode; Australian Broken Hill Consols Mine.	Yancowinna	With silver ores, in schists and hornblendic rocks	H. Wood, Min. Products, 2nd Ed., 1887, p. 43.	
Carwell Creek, Cudgegong River.....	Roxburgh ...	Slates, sandstones, and limestones.	W. B. Clarke, Mines and Mineral Statistics N. S. Wales, 1875, p. 201.	
Corinda Creek, 5 miles westerly from Woolgoolga, North Coast.	Raleigh ? ...	In ferruginous quartz ...	Mr. A. McIntosh, Grafton	
Crow Mountain, near Barraba	Darling.....	In quartz Devonian	Assay Register, Nos. 98-3,127 and 98-3,449	
Cudgegong River, 6 miles below Rylstone.	Roxburgh...	Devonian sandstones, slates, and limestone.	W. B. Clarke, Mines and Mineral Statistics N. S. Wales, 1875, p. 201; W. B. Clarke, The Sydney Magazine of Science and Art, 1857, II, pp. 157-161, 170-173; C. S. Wilkinson, Ann. Rept. Dept. Mines N. S. Wales for 1884, p. 152.	
Dungog, Calton Hill	Durham.....	(?)	Liversidge, Minerals of N. S. Wales, 1888, p. 52	
Grove Creek, near Trunkey	Georgiana...	Alluvial Pleistocene	Cat. Sydney Exhibition, 1870, p. 445	
Horseshoe Bend, Clarence River	Drake.....	Felspathic rock	T. W. E. David, Prospecting Board Papers, 91-279	
Mookerawa	Westmoreland.	(Amalgam)	S. Stutchbury, Proceedings of Executive Council, 1851, vol. I.	
Moruya	Dampier ...	(?)	Liversidge, Minerals, N. S. Wales, 1888, p. 52	
Mudgee (Cudgegong ?).....	Phillip	Sandy schist	W. B. Clarke, Cat. Paris Exhibition, 1855; W. B. Clarke, The Sydney Magazine of Science and Art, 1857, II, pp. 157-161, 170-173.	
Ophir, near junction of Great Water-hole and Frederick's Valley Creek.	Bathurst ...	(Amalgam)	S. Stutchbury, Proceedings of Executive Council, 1851, vol. I.	
Scone, near	Brisbane ...	(?)	Mr. Dickson	
Sunny Corner	Roxburgh ...	(?)	....	
Yulgilbar, Clarence River	Drake.....	Hornblende granite, and diorite.	J. E. Carne, Ann. Rept. Dept. Mines for 1895, pp. 141-144; *ibid* for 1899.	
,, Spring Creek, Clarence River.	Drake	.....	....	

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Occurrence of Mercury in New South Wales.

Historical.

The earliest official reference to mercury in New South Wales is contained in a letter from Mr. Stutchbury, Geological Surveyor, to the Colonial Secretary, from Orange, dated 9th June, 1851, in reply to an inquiry as to the presence of mercury in that district. Stutchbury was personally unaware of this, but added: "Report says it has been found near Capertee,"* a neighbouring locality, possibly confounded with Cudgegong, where, on the river of that name, about 5 miles west of Rylstone, it had been discovered, according to the Rev. W. B. Clarke, as early as 1841.†

Under date 18th October, 1851, Mr Stutchbury announced the presence of amalgamated gold, and the reported discovery of native mercury, in the Orange district, in the following terms:—"From indications of the presence of mercury exhibited at a spot near the junction of Frederick's Valley Creek, and the greater waterhole of Ophir, also on the Mookerawa Creek, where gold was shown to me in small quantities, externally whitened by an amalgam, and the parties assuring me they had seen globules of quicksilver in their cradles, and being perfectly aware that native mercury had been found in similar geological positions in Lord Rolles' Estate, High Torrington, North Devon, and near Berwick, in Scotland, and being fully impressed with the great importance of the metal in conjunction with gold-mining, I have diligently sought for it in all likely places. I have some doubt with respect to the first locality, supposing it might have escaped from some amalgamating machine; but at Mookerawa such could not have been the case, for no quicksilver had been used in the creek, and the repetition in precisely the same sort of clay—'decomposed clay slate,'—together with its identity with the North Devon case, assures me that native mercury does exist somewhere, and that possibly it may be found in quantity."

Subsequent extensive gold workings in these localities failed to reveal any further evidence of mercury deposits. Professor Liversidge's reference to Mookerawa Creek as a mercury locality is based on the above report.‡

Similar occurrences of globules of native mercury in the shallow gold-workings at the "Diamond Mines," about 6 miles easterly from Mittagong, and at Braidwood—observed by the Writer and Mr. J. B. Jaquet, Geological Surveyor—locally regarded as indigenous, are probably also attributable to escape from previously used amalgamating machines.

In 1855, the Rev. W. B. Clarke exhibited "Quicksilver in sandy schist from Mudgee."§

The same author, in 1857, in a paper on "Mercury Ores," read before the Philosophical Society of New South Wales, remarked—"In the year 1843–4, I procured from the neighbourhood of Mudgee a small sample of yellow soil, in which were interspersed several minute globules of quicksilver, which is a rare form of mercury in nature; but although the yellow colour agrees very well with a similar substance in which mercury is found in some parts of America, I have never satisfied myself as to the genuineness of the quicksilver. I have sometimes thought that it was nothing more than quicksilver spilt by the breakage of a barometer belonging to a previous explorer; for a similar accident happened to myself near Wianbene, on the head of the Shoalhaven, and someone who found the mercury on the ground imagined he had made a discovery."‖

Proceedings of the Executive Council, 1851, vol. i. † Mines and Mineral Statistics, N. S. Wales, 1875, p. 201.
‡ Minerals of New South Wales, 1888, p. 52. § Paris Exhibition, 1855.
‖ The Sydney Magazine of Science and Art, 1857, ii, pp. 157–161, 170–173.

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A similar discovery was made some years ago on the Orara River Road, between Grafton and Nana Creek, so the Writer was informed, caused by breakage in transit of a bottle containing mercury.

The proved occurrence of mercury-ore—cinnabar—about 26 miles east of Mudgee, near Rylstone, lends colour to the authenticity of the find queried by Mr. Clarke. So far as can be ascertained, native mercury has not been found in association with the cinnabar at the above locality, though both Mr. Wilkinson, the late Government Geologist, and Mr. John Anthes—who is now working the deposit for gold—state that some of the drift gold is coated with amalgam. It is well for the prospector and observant explorer to preserve open minds—caution is as necessary in rejecting as in accepting reported discoveries, practical and geological research should confirm or refute.

Further reported discoveries are recorded and commented on by Mr. Clarke in the paper quoted. "When the Hon. E. Deas Thompson was Colonial Secretary, a gentleman produced to him, either in 1850 or 1851, a bottle of quicksilver, which he stated was collected from a waterhole at which he baited his horse, somewhere near Mount Wingen. In 1852 I examined that district, with which I was well acquainted many years before, for the especial purpose of tracing the locality alluded to, and I reported to the Government that I could not find any trace of such a discovery."

Cinnabar (?), reported from Swan Hill, Lower Murray River, prior to the date quoted, was proved by Mr. Clarke and others to be an artificial product, "corrosive sublimate" (mercuric chloride).

The practical discovery and opening of the Cudgegong cinnabar deposit occurred in 1869. The facts leading up to it were briefly related to the Writer by Mr. S. L. Bensusan, who formed the first company. Having for many years maintained a private laboratory for testing minerals free of cost to prospectors, numerous parcels passed through his hands. In 1869 a sample received from Peter Dickson, of Mudgee, proved to be cinnabar. The sender, however, discredited the determination. An agent of Mr. Bensusan's was therefore dispatched to Mudgee, with portion of the original sample, in search of the mineral *in situ*, which he succeeded in ascertaining was located in Portion 35, Parish Wells, County Roxburgh. After securing the land by purchase, Mr. Bensusan visited the site, and organised prospecting operations. A rich patch of cinnabar was shortly struck in a shallow shaft (14 feet) in drift. About 5 cwt. of the ore taken from it was subsequently retorted by the late Mr. Charles Watt, afterwards Government Analyst, in a Ure's ordinary gas retort, at Barcom Glen Ice Works, belonging to Messrs. Mort & Nicolle, near Paddington.

Shortly afterwards the Cudgegong Cinnabar Mining Company was formed, with a capital of £30,000 in £1 shares. The sum of £10,000 is reported to have been expended, chiefly in surface work. A bank of three Ure's retorts were erected at the mine, with a condensing chamber. In these a considerable amount of cinnabar-bearing drift was treated with lime, but the result was very disappointing, about six flasks of mercury only being produced. A system of concentration, by grinding in a form of arrastra, and washing in ordinary puddling machines, prepared the material for the retorts, the reduction equalling about 10 tons into 1. It appears, however, from a subsequent report by Mr. Bensusan to the Company, that under this system the loss was actually greater than the saving, the sludge carrying away an equal assay value of cinnabar as the reduced material contained. The Company, in consequence, did not long continue operations, and the undertaking was abandoned.

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Wet concentration of cinnabar is at all times costly and wasteful. Vincent Spirek states that at Cornacchino mine, Monte Amiata, Italy, the tailings from wet concentration were worked over in modern furnaces, for a yield of 0·6 to 1 per cent. of mercury.*

Several reports were obtained by the Cudgegong Company on the nature and prospects of the deposit, extracts from which are of interest for comparison with later views.

In a letter by Mr. H. A. Thompson, dated October 12th, 1869, published by the Manager of the Company (Mr. W. H. Deloitte) in the *Sydney Morning Herald* shortly afterwards, it is stated that "the mine is situated on a flat at the foot of a range in this place, bounding the valley of the Cudgegong River. Here several shafts have been sunk through the alluvial deposits filling up the old tributary valley of the main river, only one of these shafts having reached the bedrock of the old valley, at a depth of 102 feet. The alluvium is of the usual character, consisting of beds of clay mixed with sand and rounded quartz. On the joints marking the separation of the different layers the cinnabar is found deposited, in many cases in grains of appreciable size, but for the most part in a state of fine powder. It is also found mixed throughout the deposits of sandy drift, and also in some of the clay beds."

. . . . . .

After alluding to reported rich finds of a misleading character, Mr. Thompson states: "A careful examination of the ground opened has, however, satisfied me that the rich patches of cinnabar there found were of limited extent, and that in taking out the alluvial ground such a large proportion of barren material must inevitably be mixed with the runs of ore as to leave no chance of such an operation being carried on profitably. . . . . ."

"It must be noted that an alluvial deposit of a hundred feet in thickness has been proved to be mixed with cinnabar throughout, and even close to the surface it is found with a modern deposit of alluvial gold."

"With so friable a material as cinnabar, a much larger proportion would be worn away and carried off by the water than has been left behind."

"It is hardly possible to suppose that the original deposit of cinnabar, whose denudation has supplied such a large amount of ore as indicated above, could be otherwise than of considerable size and richness, and the main object of the company should be to discover the position of the cinnabar vein by tracing up the alluvial deposit to its source."

The late Captain Josiah Holman, in a report dated 14th May, 1869, stated that some patches of rich ore had been struck in three shafts on an equal horizon of 40 to 50 feet; the general thickness of the richest bed averaging from 2 to 6 feet in clay formation, through which the cinnabar occurred either disseminated or in patches of higher grade. Above the horizon mentioned the mineral was more sparingly distributed right to the surface.

Carbonaceous shale was reported to have been struck at 91 feet in No. 3 shaft, which was regarded as a favourable indication, though no cinnabar was reported to occur in it.

In a later report by Mr. Bensusan, dated 23rd December, 1869, the interesting clay bed (false bottom of later observers) is mentioned in terms which the latest experience confirms:—"About 40 feet from the surface there exists a bed of clay of considerable thickness. I am informed that on the surface of this bed and in the drift above, all the cinnabar hitherto found has been obtained, but beneath it none has been met with."

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* Mineral Industry, 1897, p. 569.

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Several shafts were mentioned in the report, but one only was in use, which had been sunk to bedrock at a depth of 116 feet. At 80 feet a drive was put in towards the hill "passing through the black clay slate" crossing the drive. This no doubt is identical with the "black carbonaceous shale" of Captain Holman's report. Evidently no trace of cinnabar was discovered in the bedrock as the utility of the work was questioned by the writer.

The report dealt exhaustively with the mining and metallurgical plant and the probable causes of the failure which then confronted the Company and shortly afterwards caused it to be wound up.

Reliable estimates of the value of the drift in cinnabar and gold are not possible, but judging from the results achieved in the past, and the desultory attempts since, mostly for gold, the deposit is certainly not payable. Mr. Wilkinson, at a later date, suggested hydraulic sluicing by pumping water from the river.

Samples of cinnabar from this mine, and from a more recent discovery in the Trunkey district (probably Grove Creek, near the Abercrombie Caves, where a little alluvial cinnabar has been found with gold), were exhibited at the Sydney Exhibition of 1870.*

In 1875 the Rev. W. B. Clarke wrote:—"Some years ago I reported on the occurrence of mercury in this Colony, but my expectation of the discovery of a lode of cinnabar has been disappointed. The cinnabar occurs on the Cudgegong in drift lumps and pebbles, and is probably the result of springs, as in California. In New Zealand, and in the neighbourhood of the Clark River, North Queensland, the same ore occurs in a similar way. About 1841 I received the first sample of quicksilver from the neighbourhood of the locality on Carwell Creek, on the Cudgegong, where the cinnabar is found."† Carwell Creek junctions with the Cudgegong River immediately below the cinnabar deposit. It seems more than probable that Mr. Clarke's previous reference to quicksilver in sandy schist from Mudgee, and his later reference to Carwell Creek, refer to the same discovery.

In 1884 the late Government Geologist, Mr. C. S. Wilkinson, visited the site, and furnished the following description of the occurrence:—

"Here the course of the river makes a sudden bend from the south-east to the south-west, and across the point formed by this bend occurs a patch, about half a mile long and from 5 to 10 chains wide in places, of a very waterworn coarse pebble drift and red ferruginous sandy clays, with irregular masses of brown ironstone. This drift deposit is the remains of the old bed of the stream, which in the Tertiary period flowed down the Cudgegong Valley, the present river channel having been subsequently eroded. The ranges on either side of the river, which consist of porphyry and Devonian sandstones, shales, and limestones, rise to a height of about 250 feet, and this old drift deposit is seen to have filled the valley to a height of at least 120 feet above the level of the river. (The barometric elevation of the highest level of the drift was recently determined by the writer to be 75 feet above the river.) Old shafts and surface excavations show that a considerable amount of work has been done; but as the ground, which is private property, is now idle, I could not ascertain if the prospecting had been carried on systematically. However, Mr. Waters, the manager of a company who had the ground about six years ago, informed me that he sunk a prospecting shaft 203 feet deep, and it was then abandoned. He states that the cinnabar was found, more or less, through the drift, from the surface to a depth of 50 feet on to a false bottom,

* Cat. Sydney Exhibition, 1870, p. 445.
† Mines and Mineral Statistics N.S.W., 1875, p. 201

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and that the deposit without cinnabar continued to 117 feet, when the true bedrock of Devonian schists was met with; but at 170 feet, when in black schists, he cut through a vein 4 inches thick, dipping to the south-west, and containing a little cinnabar. He also informed me that this shaft was commenced with the object of striking, at a greater depth than it was sunk to, a ferruginous stratum which crops out on the range about 20 chains to the south, and dips to the north-east; but as this stratum is only soft sandstone, full of fossil shells, I do not think it has any necessary connection with the occurrence of cinnabar.

"Near the deep shaft Mr. Knoblanche pointed out a shaft which he and others had sunk and bottomed at a depth of 68 feet, and he also said that the cinnabar was found above the false bottom, which here occurs about 40 feet below the surface. The cinnabar taken from here occurs usually in sharp angular pieces, from half an inch in diameter down to the size of fine dust, and pieces have been obtained several pounds in weight."

Mr. Knoblanche informed the Writer that he found one piece weighing 2½ lb., and several ranging from 1 oz. to 10 oz. Mr. Anthes, after several years' experience, has found nothing larger than the pieces presented to the Writer, from 1 oz. to 1½ oz. Mr. Wilkinson's report continues:—"Often the surface of the cinnabar is somewhat rounded, but this may be the original form, and not due to attrition. I took some of the drift from close to the surface, and on washing it fair prospects of both cinnabar and fine gold were obtained; in these the grains of cinnabar were much waterworn, as might be expected, as the drift at the surface has been much denuded."

"Perhaps the most important feature connected with the occurrence of the ore is that the solid cinnabar is sometimes seen to gradually merge into or impregnate the clay or drift of the deposit in which it is found. This is, then, direct evidence that it has not been drifted by running water, like the waterworn pebbles and other material forming the old Tertiary lead, and that it has probably been derived from thermal water, which issued from the underlying Devonian rocks and permeated the Tertiary deposit."*

Mr. Wilkinson advised prospecting in the false bottom, to intersect any fissures through which the mineral water came up, which were to be followed down into bedrock. He also advised that the vein said to have been cut at 170 feet should be followed to surface. A good deal of trenching in the Devonian outcrop, higher up the ridge, has been done for this purpose without avail.

Mr. Wilkinson alluded to two adjacent ironstone lodes which he also regarded as of hydrothermal origin, but much older than the mercury springs, and thought it not improbable that cinnabar might be found in them, though he was unable to see any, nor yet in the drift alongside. These deposits have since proved to be very superficial, extending only to a few feet below the surface. A sample of the ironstone recently assayed for mercury in the Departmental Laboratory—No. 4316—yielded negative results.

Mr. Wilkinson, like Mr. Clarke, favoured a spring origin for the cinnabar, but differed in suggesting a strictly local source for its outflow. The latter, from his allusion to it as "drift lumps and pebbles," evidently regarded the mineral as foreign to the site.

According to Mr. Wilkinson's view, the mercury solutions probably rose from the immediately underlying Devonian strata or bedrock, permeating and impregnating the overburden of waterworn drift and clay. This opinion was induced by the sub-angular form of part of the cinnabar, the apparent

* Ann. Rept. Dept. Mines for 1884, p. 152.

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impregnation or merging of the mineral into some portions of the clay and drift, and doubtless to a certain extent also by the reported discovery of a vein in bedrock at 170 feet, carrying traces of cinnabar. The latter, however, lacks confirmation. Several shafts sunk and driven in the bedrock, both before and since the reported discovery, in close proximity, failed to disclose even a trace of the mineral. According to the statement already quoted, in the deep (203 feet) shaft, cinnabar was found more or less all through the drift from the surface to a depth of 50 feet on to a false bottom but not below it, thus far confirming the usual experience. Below the false bottom the Tertiary alluvial deposits are reported to have continued to true bottom at 117 feet, leaving 53 feet of blank bedrock before the small vein was struck at 170 feet.

Mr. John Anthes, who has for the past seven years been working the upper drift for gold, during the latter half of this period sank several shafts into bedrock, and connected them across the trend of the previous workings, but failed entirely in discovering the slightest trace of cinnabar below the false bottom in the drift. In one of the latest shafts, sunk under aid from the Prospecting Vote, a band of very carbonaceous shale was so heavily charged with secondary pyrites that it slacked into a black slimy mud on exposure; tested for mercury it yielded no trace.

The principal rocks encountered were sandstone and slate containing characteristic Devonian marine fossils—*Spirifera disjuncta*, &c. Similar fossils were struck in other shafts.

Several serious difficulties prevent unquestioning acceptance of a strictly local source for the mercury solutions. The proved barrenness of the lower drift beds seems fatal to an ascension theory; whilst the false bottom of clay and the upper impregnated layers of drift, indicate cessation of active deposition, and subsequent renewal with later drift material, containing cinnabar liberated by more recent denudation.

If, on the other hand, the false bottom represents an impervious bed above which mercury springs issued from the side of the valley, a reason for so tardy an outbreak without any apparent disturbing influence is hard to find; or why such waters should have failed to follow the sloping contours of the bedrock below the false bottom, which could hardly be expected to effectually prevent the downward descent at this point.

The worn and rounded form of portion of the cinnabar, regarded as possibly original, appears strongly confirmatory of attrition. Angular and sub-angular fragments adduced as evidence of local precipitation, might, *a fortiori*, be attributed to fracturing of an exceedingly brittle mineral during transport in rough bouldery drift such as that in question.

The inclusion of the angular fragments, chiefly in clay, indicates protection by muddy sediments, as the association of the finer particles with the finest clays points to prolonged suspension. Mr. Anthes confirms the statement that the coarse cinnabar occurs in the pebble-gravel, and the fine in the clay.

The merging into, or impregnation of, portions of the clay by cinnabar, alluded to by Mr. Wilkinson, might also be attributed to slight secondary deposition, a phenomenon noted in connection with the Bingara cinnabar deposits by Professor David,* and at the Yulgilbar mines by the Writer.

Probably the strongest objection to so circumscribed a source for the outflow is the total absence in the wash of the effects produced by the usual siliceous and calcareous accompaniments of mercury solutions practically the world over. Chalcedonic or opaline silica and calcium and magnesium salts are characteristic of almost every recorded instance of undoubted thermal

* Annual Report, Department of Mines, N.S.W., 1891, p. 239.

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deposition of cinnabar, and equally marked are their transforming effects on the enclosing rocks. In California an opaline or chalcedonic form of silica is so indicative as to be designated "mercury rock." Becker * states that the "gangue minerals accompanying cinnabar are nearly always silica, often in part of hydrous varieties, or carbonates, in which calcite predominates" (p. 53). "The mineral associations in which cinnabar is found seem to show conclusively that it has been deposited from solutions" (p. 55). The Cudgegong cinnabar-bearing drift is loose and friable, or simply clayey in part. The absence of a calcareous cementing medium is remarkable if mineral springs issued from the Devonian bed-rock *in situ*, for limestone is abundant in close proximity to the alluvial deposit. It occurs intercalated in the Devonian series, several outcrops being exposed at short distances south-west, west, and north of the cinnabar mines. In the ferruginous stratum mentioned by Mr. Wilkinson, on the range just above the drifts, ferruginous limestone containing Devonian marine fossils occurs.

Furthermore, it is doubtful whether thermal aqueous action is ever unaccompanied by more or less siliceous solution and redeposition, usually in colloidal form, particularly when, as in this case, siliceous rocks are traversed. Evidence of such phenomena being absent from the drift deposits is, however, supplied by portion of the cinnabar itself, betraying its common origin and association. Several specimens recently presented to the writer by Mr. Anthes, weighing, as before stated, from 1 oz. to 1½ oz. each, throw clear light on the subject. In these specimens the cinnabar invests and penetrates the usual secondary form of silica. Cavities also occur which may represent one or other of the usually-associated carbonates of lime or magnesia. The specimens, moreover, are clearly water-worn, and may thus be accepted as undoubted evidence of vein or fissure deposition, degradation, and transport.

The original spring, or thermal aqueous origin assigned to the cinnabar, is not weakened by these facts, which merely refer to location. The actual site of the outflow is an unsettled question which has been brought into prominence here solely for the purpose of encouraging search beyond the restricted site of much unprofitable labour and expenditure. To this end an impartial statement has been made of the facts and opinions adduced by observers bearing upon the subject, for mere suggestions frequently become accepted facts, solely through time and repetition, and tend to direct research into restricted grooves.

The time, moreover, is opportune for reviving the unsolved problem of origin or derivation, as an Adelaide syndicate has begun prospecting for the source of the cinnabar at the instigation of Mr. Anthes. A costeen has been cut across the spur, about 150 yards south-westerly from the deep shaft. Above this point no cinnabar has been found. Two shafts have also been started. One passing into bed-rock at 30 feet from the surface, was abandoned at 44 feet. The second is being sunk close to the former, on the dip side, and at 30 feet was still in drift, as might be expected. The only additional fact so far demonstrated in these operations is, that the false bottom of clay, which attains a thickness of 6 or 8 feet in the old workings, is overlapped by the later accumulations. The Devonian beds have been folded into a series of wavy anticlines and synclines, and one of the former striking across the old valley in a north-westerly direction, determined the course of a ridge which has dammed back the deep accumulation of drift which fills the hollow or trough of the corresponding syncline, whilst a shallow sheet of the latest and highest drift passed over the obstruction.

* Geology of the Quicksilver Deposits of the Pacific Slope. U.S. Geol. Survey, Mon. xiii, pp. 53 and 55.

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Though cinnabar has not been specially identified with any particular geological period or lithological formation, yet, according to the associations of many notable deposits, those of the Cudgegong Valley immediately surrounding the local deposit appear favourable. In close conjunction are sandstones, conglomerate, shales, limestone, and intrusive porphyry. Search is desirable in and near the limestone, because of the extensive association of this rock with cinnabar, particularly in Mexico; also at and near the junction of the igneous and sedimentary rocks, and particularly up the course of the Cudgegong Valley.

It is noteworthy that the drift, particularly the coarse upper layers, contains red jasper and cherty pebbles and boulders, which are not representative of any of the closely-adjacent rocks. The nearest approach to a similar formation *in situ* is a chalcedonic and ferruginous outcrop at the junction of porphyry, limestone and sandstone on the opposite side of the river, about half a mile from the cinnabar drift. This will shortly receive some attention from Mr. Anthes, who examined it in company with the Writer.

To add to the difficulties of determination, it is confidently asserted by both Mr. Anthes and Mr. Knoblanche, that practical trials have failed to discover any trace of cinnabar above or below the present site on the river, though Mr. Clark recorded Carwell Creek as a cinnabar locality. This stream, as already stated, junctions with the Cudgegong just below the Cinnabar Mine.

In view of subsequent denudation, and redistribution of portion of the Cinnabar drift by the medium of the present river channel, it is impossible to accept at least a part of this assertion as conclusive; nor should the failure of previous efforts deter a further and more systematic effort to trace the mineral up stream to its source.

Mr. Warden Snape, referring to the Cinnabar deposit, wrote of the "well-known fact that quicksilver ore exists among the Cudgegong mountains,"* but did not substantiate the announcement by any definite instances of locality or occurrence, nor have any since been recorded.

In "Mineral Products of New South Wales," 1st Edition, issued by the Department of Mines in 1882, p. 89; and again in his "Minerals of New South Wales," London, 1888, p. 52, Professor Liversidge quotes "Mines and Mineral Statistics of New South Wales, 1875, p. 201," in reference to the reported occurrence of mercury at Wagonga, on the South Coast, "in a bed some 10 feet thick, about 90 feet above sea-level," which is evidently a mistake, as no mention is made of the fact in the work quoted, nor is anything known of the reported occurrence.

Mercury is also reported in the same work "in the casing of the Clifton Reef, Boorook"; and with cinnabar in a "clay lode, and in the surface grit at Calton Hill, Dungog."

In the 2nd Edition of "Mineral Products," 1887, p. 43, Mr. Harrie Wood, Under Secretary for Mines, records the Barrier Range as another cinnabar locality.

From the Australian Broken Hill Consols Mine, samples of cinnabar have been presented to the Mining Museum by a former Manager—Mr. George Smith. In the same institution are specimens of "iodide of mercury," deposited by sublimation on the sides of the vent cracks in the open cut workings in Broken Hill Proprietary, Block 11, since the outbreak of fire in the lower levels of that section. Iodide of copper—marshite—occurs in the Broken Hill lode, and iodine has since been detected in cuprite from the same lode. Possibly mercury occurs in the form of cinnabar in the Broken Hill

* Ann. Rept. Dept. Mines N. S. Wales for 1882, p. 49.

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lode, where iodide of silver also is common, and a new combination of the two volatile metals—mercury and iodine—has been set up by the action of the fire in Block 11, though the natural iodide of mercury may be present as *coccinite*.

The latest discovery of mercury ore in the Colony is described by Mr. A. M'Intosh, of Grafton, as occurring on a branch of Corinda Creek, about 5 miles westerly from Woolgoolga on the North Coast. Two samples from this locality, consisting of ferruginous quartz with cinnabar, have recently been assayed in the Departmental Laboratory, with the following results:—$\frac{a}{0}\frac{a}{0}^{1}$, mercury, 0·26 %; $\frac{a}{0}\frac{a}{0}\frac{a}{0}$, mercury, 0·30 %. Gold and silver traces in each case.

For a number of years cinnabar was found in alluvial gold-workings at Spring Creek, close to Bingara. Some fairly coarse worn fragments were presented to the Mining Museum by Mr. Grosbernd, of that town. In 1890 the mineral was discovered in serpentine at the locality mentioned, and shortly afterwards was examined and reported on by Professor David.* The following extracts are from his report:—"Three distinct geological formations are represented, as follows:—

"1. Claystones and limestones, probably of Siluro-Devonian age.
"2. Serpentine, resulting from the alteration of an ultra-basic rock of a decidedly intrusive nature. The lode deposit of cinnabar belongs to this formation.
"3. Alluvials, probably of recent geological age, derived from the breaking up of the claystones, &c., and serpentine, by streams of fresh water and other natural denuding agents.

"The claystones and limestones at Spring Creek strike in a N.N.W. direction, and dip E.N.E., at from 60° to 70°. The limestone bed appears to have a thickness of at least 100 feet, probably more, and is evidently stratified with the claystones." . . . . .

"The serpentines at Spring Creek occur in the form of an eruptive dyke mass, from 3 to 5 chains wide, striking either north-westerly or northerly."

At the time of inspection lode cinnabar had been found in only two shafts, 40 and 25 feet deep, 15 feet apart. The deposit is described in the report as having no true walls, being, in fact, a dyke of decomposed serpentinous rock, with interstratified layers of soft purple clay shale. The limits of the productive portions of the dyke could only be ascertained by constant testing as the work advanced.

"The cinnabar is disseminated chiefly through the mass of the dyke in small spots, from the size of a small pin's head up to that of a pistol bullet. It also occurs in thin films in joints in the dyke. The dyke has so far been proved to be cinnabar-bearing for a length of about 15 feet, with a maximum width of about 3 feet 6 inches, and a depth of 40 feet, this last being the maximum depth attained in the shafts. Although the greater part of the dyke material comprised within these measurements carries traces of cinnabar, the greatest measurements of any portion of it which may be described as being decidedly cinnabar-bearing were represented to us as being about 5 feet high, 4 feet long, and 1½ foot wide." A sample weighing 10 lb., carefully selected by Professor David from the bottom of the 25-foot shaft, was crushed and divided into two parcels, one of which was treated by the dry method, and the other by the wet, with corresponding results, viz.—metallic mercury, 0·01 per cent.

"Summary.—From the occurrence of the cinnabar along the line of contact of an eruptive dyke with a sedimentary rock, it is likely that the dyke will

* Ann. Rept. Dept. of Mines N. S. Wales for 1891, pp. 234–239.

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continue to be cinnabar-bearing to a considerable depth, as most contact deposits of this kind show great permanence when followed downwards; unless, however, the dyke stone improves considerably at a depth in its yield of cinnabar, it is improbable that the deposit will prove payable."

Aid from the Prospecting Vote was granted to the best site indicated above, to enable a deeper test to be made (Pros. Papers, 91–1073), but at 78 feet work was abandoned, ostensibly on account of influx of water. Traces of cinnabar were reported to continue to the depth mentioned.

Professor David also visited, in the same year, the site of the first discovery of cinnabar, in the Upper Clarence district, made by Messrs. Kelly Brothers in M.L. 5, Parish Carnham, County Drake, about 3½ miles south-east of Lionsville, and described the occurrence in the following terms:—"A dyke, 12 feet wide, of felspathic rock allied to serpentine, containing cinnabar, distributed irregularly in spots and minute veins. This dyke has intersected the granite of the district at this locality, and is likely, I think, to be permanent to a considerable depth." Aid was granted to continue sinking, but was not availed of,

In 1895 a more important discovery was made, about 7 miles north-east of Lionsville, on which the following report was furnished by the Writer:—

Report on a Deposit of Cinnabar near Lionsville.

Geological Survey Branch, Department of Mines and Agriculture,

Sir, 3 January, 1896.

I have the honor to report that, in accordance with your instructions, I have inspected the recent discovery of cinnabar on Yulgilbar Station, Clarence River.

The deposit occurs about 5 chains from the south-west corner of portion 15, parish Ewengar, county Drake, and about three-quarters of a mile west of the Clarence River.

The nearest settlement is Lionsville, distant about 7 miles in a south-west direction.

The discovery was made by Laurence Fox about twelve months ago through picking up a loose surface specimen of the matrix containing cinnabar. Actual prospecting began in February last.

A previous discovery was recorded in this district in 1891 at Horseshoe Bend, about 16 miles lower down the course of the river, and about 3½ miles south-east of Lionsville. This site has been surveyed as M.L. 5, of 40 acres, in the parish of Carnham. Mr. Geological Surveyor David reported on this deposit about March of the same year, and recommended aid from the Prospecting Vote for proving it. The occurrence is briefly described as* a dyke, 12 feet wide, of felspathic rock, allied to serpentine containing cinnabar, distributed irregularly in spots and minute veins. This dyke has intersected the granite of the district at this locality, and is likely, I think, to be permanent to a considerable depth."

The present report will be limited to a brief description of the country rocks, nature and apparent mode of occurrence of the mercury ore, present and suggested future prospecting, &c.

To attempt an estimate of the richness of the deposit, or of the quantity of ore likely to be available at the present initial stage of exploration, would be unfair, even if not altogether impossible. Sufficient data, however, will be adduced to justify the opinion that the prospects are decidedly encouraging, and far superior to those afforded by any previous discovery recorded in the Colony.

Previous Discoveries and Mention.

The localities of previous discoveries with reference to reports thereon may be briefly summarised as follows:—

Locality.	Authority.
Near Rylstone, Cudgegong River, county Roxburgh.	Rev. W. B. Clarke, Min. Statistics N.S.W., 1875, p. 201.
Mookerawa, and Great Waterhole of Ophir, county Westmoreland.	Prof. Liversidge, Min. N.S.W., p. 52.

* T. W. E. David, Prospecting Board Papers, 91–279.

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Locality.	Authority.
*Clifton Mine, Boorook, county Buller	Prof. Liversidge, Min. N.S.W., p. 52.
Wagonga, county Dampier.....	,, ,,
Moruya, county Dampier	,, ,,
Calton Hill, Dungog, county Durham	,, ,,
Grove Creek, Abercrombie Mountain, county Georgiana.	,, ,,
Near Scone, county Brisbane.....	Mr. Dickson.
Spring Creek, near Bingara, county Murchison.	T. W. E. David, Ann. Rept. Dept. Mines N.S. Wales for 1891, p. 234.
†Crow Mountain District, near Barraba.	
Horshoe Bend, Clarence River, county Drake	T. W. E. David, Pros. Board Papers, 91-279.

Whilst writing this report a sample of galena and zinc blende with cinnabar has been brought to the Geological Survey Offices for assay, with a statement that it was obtained from Sunny Corner, Mitchell, county Roxburgh.

General Geological Features.

The country at the cinnabar deposit consists of hornblende granite, felsite, and augite-diorite, whilst in the immediate neighbourhood serpentine is largely developed.

The sedimentary rock of the district consists of altered slate, which has been referred to the Devonian formation by the late Government Geologist, Mr. C. S. Wilkinson.‡ The gold reefs of Lionsville occur in the latter where it has been intruded by granite dykes.

The special feature of the most important mercury mines of the world, viz., association of igneous rocks with sedimentary strata, is absent in the present case. So far as yet proved ore is confined to the igneous rocks.

Prospecting Operations.

At the time of inspection in October last prospecting operations had just been resumed after a short respite. Two shafts have been sunk 20 feet and 50 feet respectively about 3½ chains apart on a line bearing N. 15 degrees E., and S. 15 degrees W. These shafts are on distinct veins, which have an east and west trend. (?)

From the 50 feet shaft a line of shallow surface openings has been extended for about 29 chains in a direction 25 degrees north of east. These openings have been made wherever any of the characteristic fine-grained felsitic and chalcedonic matrix appeared at surface. In some instances the openings have been on loose and isolated boulders; in others, however, there is evidence of veins *in situ*, but not sufficiently pronounced to allow of a definite strike being determined for the complete line. It appears more likely that these veins are numerous. Traces of cinnabar were detected in most of these openings, but nothing approaching payable ore.

A second line of shallow openings has been made along a well-defined outcrop of similar rock. This line bears E. 5° S. from a point 80 links south of the 50 feet shaft. The openings extend for about 16 chains east from the shaft; the outcrop, however, can be traced at least twice that distance to the Clarence River, near the west bank of which it forms a bunch or "blow." Some years ago this bunch was prospected for gold. Cinnabar could not be detected here, though numerous freshly broken specimens were examined. I was informed, however, by Mr. T. Bassetti, one of the shareholders of the Cinnabar Mine, that that mineral could be identified upon crushing and washing the samples of the rock.

At the spot marked (C) on plan an opening 7 feet deep has been made in the outcrop referred to, and from that level a small opening or drive has been put in about 4 feet south. At the extreme north and south limits of the opening and drive, hornblende granite is exposed, the intervening rock being felsite, both being much weathered and decomposed. The peculiar feature here represented is the horizontal banding or marking of the rotten felsite by finely divided particles of cinnabar. The decomposed felsite is about 7 feet thick, and carries a small percentage of mercury—about one half per cent.—throughout that thickness. This site is one of the most favourable for prospecting.

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* These occurrences are evidently based on verbal or non-published reports; hence the references are non-committal.—J.E.C.

† Samples from this locality, Nos. 98-3,127 and 98-3,449, assayed in the Departmental Laboratory, yielded 11·2 and 3·0 per cent. of mercury, the matrix being quartz. No particulars are available of these occurrences.—J.E.C.

‡ Ann. Rept. Dept. Mines N.S. Wales for 1889, p. 202.

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Detail of prospecting and appearance of ore in the workings.

The main 50 feet shaft being timbered for about 20 feet from surface, an examination of the appearance of the ore-veins near the surface could not be made for the purpose of comparison with those presented in the shallow openings above described. Below the timbering the discolouration obscured all traces, if any existed, of the ore to within a few feet of the bottom. In the south-eastern end of the shaft thin veins of cinnabar traverse irregularly about one foot of felsite country. In the north-western end a little cinnabar was just beginning to show at the bottom of the shaft.

Specimens of cinnabar were taken out at the upper levels several inches thick; the individual veins, however, at the 50-feet level have narrowed to about 1 inch at thickest. Little importance attaches to this pinching or thinning, because of the capricious occurrence of the cinnabar. Bunches of greater thickness are certain to be met with at intervals where vughs or cavities have been formed in the country.

From the 50-foot level a start has just been made to cross-cut southerly in the direction of the 20-feet shaft. The first shot had broken off a thin skelp from the side of the shaft, which revealed thin veins and faint impregnations of cinnabar traversing and colouring the felsite country. The actual thickness of the ore-body at this point cannot, therefore, be determined until the drive has been extended. A cross-cut in the opposite direction would also, perhaps, reveal an extension of the cinnabar in the country.

At the 20-feet shaft, the cinnabar, quartz, and calcite form the filling of a contact fissure between an intrusion of augite-diorite and the felsite. The cinnabar in the best specimens averages, perhaps, 1 inch in thickness in this vein.

The appearance of the ore in the small opening marked (*c*) has already been described. In the shallow openings, as has been mentioned, traces only of cinnabar have as yet been exposed.

Probable Mode of Occurrence of the Cinnabar.

As far as the limited amount of prospecting will allow of an opinion being formed, it appears probable that three or more parallel bands of felsite occur, containing veins and impregnations of cinnabar.

The ore-band on the 50-feet shaft is evidently distinct from that in the main line of outcrop, which strikes about 52 feet south of the shaft, because the felsite in that outcrop, as exposed at the opening marked (*c*), is but 7 feet thick, between well-defined hornblende granite walls.

A third band is represented at the 20-feet shaft, and possibly a fourth in the most northern line of openings.

Nature of the Country or Enclosing Rocks.

Characteristic specimens of the country rock were selected and forwarded to the Geological Survey Office for petrographical examination and determination. The following notes upon them have been kindly supplied by the Curator and Mineralogist, Mr. Card, A.R.S.M. :—

"Three types of rocks are comprised—

"(*a*) Fine-grained felsite of a greenish colour, weathering brown when fresh. This is the principal cinnabar-bearing rock, the ore occurring in veins and spots closely associated with quartz, and, to a less extent, calcite. These three minerals—cinnabar, quartz, and calcite—are of secondary origin; they do not occur in fresh, unaltered calcite, but their presence is always correlated with a general alteration of that rock. Pyrites is very generally present, but does not appear to possess any significance with regard to the origin of the cinnabar ore.

"(*b*) A holocrystaline rock marked "country." This consists of quartz, felspar, orthoclase, and much oligoclase (?) hornblende and a little magnetite, may be classed as hornblende-granite. A much altered form of this rock is of great interest, in that the alteration has been accompanied by an introduction of cinnabar, which occurs in small particles within the decomposed felspar, and more abundantly along the divisional planes of the hornblende.

"(*c*) Two specimens of fine-grained augite-diorite from No. 2 shaft."

Mr. Card's opinion as to the secondary nature of the cinnabar and associated minerals in the felsite and hornblende-granite, derived from microscopic examination of selected specimens is entirely confirmatory of the decision I arrived at in the field.

Though the cinnabar is mainly confined to the felsite bands, yet evidence is not wanting, macroscopic as well as microscopic, of a certain amount of impregnations of the granite itself.

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The calcite and quartz occur in veins as well as impregnating the mass of the altered felsite. Small vughs occur which are lined with the crystal faces of the calcite. It is noticeable that when the cinnabar occurs as a vein, no matter how thin, it is entirely associated with the quartz, and separate from the calcite. In no instance in the vein-specimens collected could cinnabar be detected in the calcite. The quartz filling the veins has a translucent appearance passing almost into clear glassy transparency near the metallic vein minerals. Its outer surfaces form a series of mammillary curves covered with free terminating crystals. On these the calcite has been deposited. Part of the calcite is dark greenish-black; the colouring matter may be due to chlorite from decomposition of hornblende.*

The felsite in its normal condition is very fine-grained and greenish in colour, breaking with acherty conchoidal fracture. Pyrites is fairly abundant in it. Where decomposition has been set up the texture of the rock has become more closely crystalline in appearance owing to the replacement of portion of the fine felspathic material by crystalline calcite. The extent of the replacement may be judged from the following determination of the lime in an average specimen of the felsite from the bottom of the 50-feet shaft=Lime (CaO) 11·17%, equal to carbonate of lime 20·89%.

Nature of the Ore.

Associated with the cinnabar is an almost tin-white mineral, weathering bronze, containing copper, antimony, and sulphur. The copper carbonates, which occur in small quantity in the upper levels, have resulted from the oxidation of this mineral. The association of the latter with the cinnabar is too intimate to allow of the perfect separation necessary for adequate test for mercury in it. A complete analysis, however, of the mixed ore has been made by the Analyst to the Department, Mr. J. C. H. Mingaye, F.C.S., with the following results :—

Chemical Composition.

Metallic Mercury	43·68
,, Copper	6·87
,, Antimony	4·44
,, Arsenic	trace
,, Iron	·55
Alumina	trace
Lime (CaO)	1·26
Magnesia (MgO)	·21
†Gangue	30·46
Sulphur	11·46
Carbonic Acid	·44
Moisture at 100° C	·25
	99·52

Fine silver, at the rate of 9 oz. 6 dwt. 4 gr. per ton } No tellurium or
Fine gold, a trace (under 2 dwt.) } selenium detected.

The copper-bearing mineral penetrates the vein quartz in wedge or cone-shape forms. Mr. Card, who examined all the selected specimens prior to my return, suggests that it may be a mercurial fahlerz; further exploration may furnish sufficiently pure specimens for actual determination.

The first specimen of cinnabar from the Yulgilbar deposit assayed in the Departmental Laboratory yielded :—

Metallic mercury, 60·70%.
Silver, 6 oz. 10 dwt. 15 gr. per ton.
Gold, a trace (under 2 dwt. per ton).

This sample represented the highest grade ore in the principal vein near the surface of the main 50-feet shaft. The following samples were selected by myself from a band of decomposed felsite about 7 feet thick in the small opening at the spot marked (c) on plan.

[4057] "Picked." Decomposed felsitic material forming horizontal pink layers from 1 to 2 inches thick in a vertical section of about 3 ft. 6 in. :—

Metallic mercury, 48%.
Copper, a minute trace.
Neither gold or silver.

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*Since determined to be owing to inclusions of fine acicular crystals of stibnite.
† Chiefly silica.

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[4058.] "Average." Decomposed felsitic material, being an average sample selected from the full thickness in the above section :—

Metallic mercury, 50%.
Copper, a minute trace.
Neither gold or silver.

From the pink colour of the horizontal layers a much higher yield would have been anticipated from the "picked" sample than from the average of the whole thickness.

The cinnabar in the soft decomposed felsite must be in a very fine state of division, for its presence is only detected by the faint pinkish tinge imparted to the matrix. Possibly portion of the cinnabar may have been removed during the decomposition and weathering, as a sample of undecomposed felsite, having a pink tinge from included cinnabar, from No. 2 shaft, yielded as follows :—

[4056] "Lump."

Metallic mercury, 1·58%
Copper, a minute trace.
Neither gold nor silver.

Hence it is reasonable to expect a higher yield from the undecomposed felsite at a depth at the spot marked (C) on plan.

Origin of the Cinnabar.

Field observation and microscopic examination alike agree as to the deposition of the cinnabar from solution in siliceo-calcareous waters which percolated through definite cracks or fissures, and soaked laterally into the country as the corroding solutions attacked its more soluble constituents, and replaced them chiefly from the calcium or lime salts in solution.

It would, however, be premature to offer an opinion as to whether the mercury salts had a deep-seated extraneous source, or were originally leached in minute quantities from the contiguous or underlying granite and redeposited in the way described.

Ore at Grass.

Some of the richest patches of ore have been bagged, but little care has been taken with the bulk of the stone raised from the shafts ; hence any estimate of quantity of workable ore—fixing 5 per cent. as the maximum in this case—would be very approximate only. It is certain, however, that a fair proportion of the above grade ore could still be culled from the waste.

Further Prospecting.

The crucial question at the present moment, however, is—what quantity of workable ore is likely to be available in the mine?—a question which requires a practical answer such as systematic prospecting alone can give.

The sites most likely to afford a solution to the query would be the present shafts (A and B) and the site marked (C) on the accompanying plan. The prospecting should be in the direction of deepening the above shafts (including C), driving along the course of the veins, and crosscutting to ascertain the thickness of ore-bearing country.

Conclusion.

I am of opinion, from the mode of occurrence, that the cinnabar is likely to continue to great depths, but whether in sufficiently concentrated form to pay for extraction prospecting alone can prove.

The conditions of occurrence differ from those of the very few paying mercury mines of the World, yet the prospect of developing a paying deposit of moderate extent is decidedly encouraging and certainly superior to any yet obtained in the Colony.

As the existence of a mercury mine in Australia would be of first importance in such a gold-bearing country, I am of opinion that a share of the cost of proving comes well within the scope of the Prospecting Vote.

I have, &c.,
JOSEPH E. CARNE, F.G.S.,
Geological Surveyor.

The Government Geologist.

In August of the present year a second visit of inspection to the Yulgilbar mine was made by the writer, for the purpose of noting developments to date. Whilst engaged upon the work, the Great Australian Quicksilver-mining Company, Ltd., was formed to secure and develop the property on more systematic lines than yet adopted.

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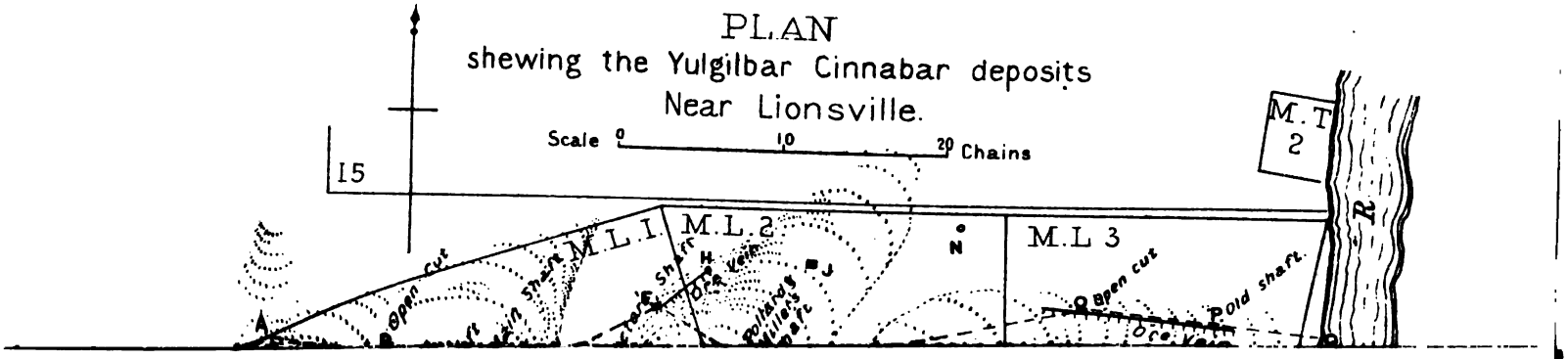

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After the first inspection in 1895, aid was granted to the prospectors—Bassetti and Party—to deepen the main shaft, and sink another at a spot indicated. The former was carried down to 95 feet 6 inches, and then temporarily abandoned. The site of the second aided shaft in M.L. 2, was forfeited by the original holders, and shortly afterwards secured by Miller, Pollard, and Party, who sank 58 feet 6 inches. Again abandoned, it is now included in the new company's property. At a later date, through the agency of Dr. Flateau and others, two additional shafts were sunk about 26 and 30 feet, and an open excavation made on a later discovery.

Several distinct lines of cinnabar-bearing veins, proved by later developments, have been charted on the accompanying plan, and illustrated in section. Distinctive letters on the plan and in the text denote the position and identity of the workings.

The extension of prospecting has demonstrated two facts, viz., (1) a larger amount of cinnabar-bearing rock than formerly visible, and (2) the probable dependence of future operations upon the value or workableness of the lower-grade deposits, which alone offer sufficient promise of quantity commensurate with successful working, for it goes without saying that a minimum yield can only be set off by large, cheap, and rapid output.

Unfortunately the grade of the ore in the latest developments is disappointingly low, bordering so close, if not quite, on the unworkable as to put the contemplated immediate erection of reducing furnaces altogether out of the question at this stage. The first and most pressing necessity is extensive proving on systematic lines, and for this there is both justification and inducement.

The hopes engendered by recent experimental tests of a small quantity of picked ore are discounted by the limited supply of such grade in view. It is, therefore, imperative that the prospective supply and value of the larger deposits should be definitely determined by extending prospecting before a reduction plant is considered.

The brilliant hue of cinnabar—"vermilion"—renders it an intense colouring agent; hence an infinitesimal proportion imparts a very deceptive appearance to a veinstone or impregnated rock. Some of the highest-coloured and most promising-looking portions of the Yulgilbar ore are so lightly charged with this mineral as not to sensibly affect the specific gravity of the matrix. When it is remembered that cinnabar is a heavy mineral, possesssing a specific gravity of nearly 9 as compared with 2·6 to 2·7 of the matrix, the disappointing assay results of such samples can be more readily comprehended.

The principal samples selected by the Writer for assay during recent examination were subjected to the specific gravity test in confirmation of the laboratory results obtained. Further microscopic examination of prepared sections of the impregnated veinstone and enclosing rocks reveals at a glance the fineness and paucity of the colouring agent.

Active prospecting had ceased for some little time at the mines, but the Proprietary placed the workings in order, and afforded every assistance during the week devoted to inspection.

It will be seen by the plan that at least four distinct veins have been located, and more or less superficially tested; the most important, probably, being the junction line with the diorite dyke which intrudes the hornblende-granite country. Here the largest defined ore body is exposed, which, from its mode of occurrence, is likely to prove permanent to great depths. An interesting feature is the impregnation of both contact rocks with cinnabar, extending to at least the full width of the shaft (G). From the field and microscopic

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evidence, it would appear that solfataric mineral solutions, containing mercury and a little antimony sulphides, followed the diorite intrusion along contraction fissures, permeating both dyke and country for a distance as yet unproved.

The diorite dyke is traceable on the surface from shaft G, through M.L. 1, and beyond, and has also been exposed in shaft E, and open cut R, as well as in small openings between G and E.

At E and M exactly similar surface conditions exist as at G. The dyke is very narrow—from 2 to 6 feet wide. Notwithstanding the discrepancy in strike, it is probable that the veinstone at O and P, near the Clarence River, agrees in more than resemblance with the dyke lode noted further west.

Geological Features.—An alteration in the nomenclature of the previously-recorded geological formations has been rendered necessary by extended field research and petrological examination of rocks from lower levels. The deceptive-looking formation previously described as felsite and altered felsite, proves to be lode material, a product of the transforming effects of the investing mineral solutions.

Becker states that "the rocks adjoining ore deposits have in many cases been greatly modified. Metamorphic rocks often appear to have been converted into or replaced by more or less dolomitic carbonates by the action of solutions."*

The following additional notes on the petrology of the field, by Mr. G. W. Card, A.R.S.M., are the results of later study of fresh specimens collected by the Writer :—

"'2068'. *Country Rock.*—Medium-grained crystalline, of a prevailing green tint, due to the presence of hornblende. Quartz, hornblende, orthoclase, and plagioclase are conspicuous in hand specimens.

"Under the microscope the felspars are seen to be zoned, and intergrowths of the two varieties are common. Nests of micro-pegmatite are present. The rocks may be most conveniently designated hornblende-granite (granitite of some authors).

"'2056'. Influenced by proximity to the vein. Felspar is clouded beyond recognition; hornblende has been completely altered; iron ores and cinnabar are disseminated through the mass, which is also traversed by calcite veins. In places it shows an approximation to a graphic structure.

"'3612'. From G shaft, showing a junction between the veinstuff and country rock. Both are cinnabar-bearing, and the line of contact is marked by the presence of antimonite.

"Under the microscope the cinnabar—along with the metallic ores—is seen scattered through the clouded felspar and vestigial hornblende. The junction with the veinstuff is marked by a narrow band of the latter, consisting of crystalline quartz with some calcite, enclosing blotches of cinnabar. This rapidly verges into a crypto-crystalline siliceous mass containing some calcite, throughout which cinnabar dust is scattered.

"'3621'. G shaft. From the dyke traversing the field. A compact pyritous green rock, with lighter mottling, due to a greenish-white felspar.

"Under the microscope it is seen to consist of plagioclase (perhaps an andesine variety), residual hornblende, chlorite, some quartz, calcite and iron ore. It is doubtful how far the quartz is primary.

"'3611'. From E shaft.—Under the microscope this has the appearance of being a portion of the dyke, highly weathered and mineralised. It is very fine-grained, and carries cinnabar.

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* Geol. of the Quicksilver Deposits of the Pacific Slope. U.S. Geol. Survey Mon., xiii, p. 292.

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"A variation in colour suggested the possibility of a junction between different classes of rocks being represented, but the appearance is due to different degrees of weathering.

"'2064'. From E shaft.—Two specimens taken from the tip at different times. A very compact pyritous green rock, with a specific gravity of 2·87; glancing hornblende and lath-shaped felspar can be detected with a lens.

"Under the microscope it is seen to consist of lath-shaped and much altered plagioclase with some orthoclase, prismatic green hornblende, abundant pale green chlorite and granular, practically colourless, epidote, calcite and quartz. The latter mineral increases in abundance with the epidote, and is associated with it, sometimes showing crystal faces.

"It is possible that the epidote and quartz together may represent the larger felspars (probably lime-bearing) of '3621'. There is a slight tendency to an ophitic relationship between the chlorite and the felspar laths.

"The most suitable classification of this rock presents a difficulty. For general purposes it will, perhaps, be best to designate it a fine-grained quartz diorite. Scientifically, its somewhat peculiar constitution and structure, together with its fineness of grain, would bring it near the lamprophyres or aphanites.

"NOTE.—Although the chlorite might represent augite, that mineral is not certainly present, and the granular mineral, I am satisfied, is epidote. The designation, 'augite diorite,' applied by me on a former occasion to a specimen from E shaft cannot, therefore, be retained.

"'3622'. *The veinstuff*, from F shaft.—This consists essentially of impure calcite. Through this the cinnabar is scattered in small blotches, minute rods, and dust. It is associated with an equally finely-disseminated metallic ore—magnetite to some extent. The ore is traversed by thin strings of pyrites.

"Several other specimens were also examined. The siliceous vein-stuff is very compact, presenting, both megascopically and microscopically, a close resemblance to felsite. The earlier specimens were so regarded, but an examination of an extended series points to a purely secondary origin from the whole."

Further Development.

The main shaft (D on plan) has been deepened from 50 feet, recorded in the first report, to 95 feet 6 inches, and a level has been extended 11 feet easterly at 36 feet from surface. Close timbering obscures any inspection above the level; below it the shaft is inclined about 25° from the vertical, following the underlay of the vein southerly.

The face of the level shows a slight impregnation of cinnabar in the foot-wall. Evidence of fissuring is afforded by a vugh of considerable size, lined with chalcedonic silica.

Below the close timbering to the bottom of the shaft, a distance of about 59 feet 6 inches, the vein-stone averages from 4 to 7 inches in thickness, and is well defined at the lowest level. Slight impregnation of the country occurs in places, but the quantity of cinnabar is inappreciable. In the vein the cinnabar occurs as occasional streaks from ½ to 1 inch thick; sometimes two parallel streaks occur about 1 inch apart. The productive portions of the vein-stuff range from 1 to 3 inches in width, but are not continuous; in fact, all trace of cinnabar occasionally disappears for some distance. An idea of the irregular occurrence of the mineral in the matrix, both vertically and horizontally, is gained from its appearance in the shaft and drive. The ratio of cinnabar-bearing to barren matrix equals about 1 in 4 vertically.

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A considerable amount of the full width of the vein exposed in the ends of the shaft at 93 feet was gadded out and brought to surface, where the best—or coloured—portion was picked out, broken small, and carefully sampled in the usual way, by mixing and parting. In the Departmental Laboratory large assays, in duplicate, of this material yielded (No. 3,373) at the rate of 1·09 per cent. of mercury. An average sample of the balance of the vein-stone extracted, similarly treated, yielded (No. 3,372) no mercury. The specific gravity of large pieces of these samples ranged from 2·69 to 2·71.

From the nature of the vein-stone, and the capricious occurrence of the cinnabar, it is apparent that a large amount of vein material—apart from the country extracted for the proper dimensions of the shaft or level—would have to be mined in proportion to the workable ore obtained by spalling and picking. Calculated on a specific gravity of 2·7 a cubic foot of vein-stone would weigh about 168 lb., or 13 cubic feet, to the ton. Accepting, on the evidence of the shaft, the proportion of workable ore as 1 to 4, 52 cubic feet of vein-stone would have to be mined to yield 1 ton of 1 per cent. ore.

As richer streaks of ore were found nearer the surface, allowance must be made for more favorable developments than at present visible. Possibly an additional per cent. could be safely allowed, bringing the average grade of the picked stone up to 2 per cent.

The ore recently experimented on in Sydney before the Directors and others of the newly formed Mining Company, was picked from the material raised during sinking of the main (95 feet) and a neighbouring shaft.

Though this vein is not in itself workable on account of the thinness and discontinuity of the ore-bearing streaks, it must be taken into account in estimating the possibilities of the whole property.

From the bottom of the main shaft strike levels are required, and a cross-cut to the dyke-lode, to intersect any intervening parallel veins that may exist. The dyke-lode would be cut from this level about 100 feet below its outcrop.

About 120 feet from the main shaft on the western strike, a more recent shaft (C) was sunk to about 30 feet. Time did not permit of it being unwatered. Judging by the tip, however, the vein in the granite is very narrow, and the impregnation of the country slight.

About 8 chains still further west, apparently on the same line, a small opening reveals the usual chalcedonic veinstone containing a little stibnite (stellate), pyrites, and cinnabar.

About 12½ chains E. 18° 20′ N. from the main shaft is another recent shaft (F), locally known as "Doctor's" shaft, sunk 26 feet on the most northern vein, represented by shallow openings at the time of first inspection. The strike of this vein taken in the shaft is N. 55° E., with a slight south-easterly dip.

The shaft is closely timbered to within a few feet of the bottom. Removal of timbering at 14 feet revealed the same thickness of veinstone as at 26 feet, viz., 12 to 14 inches, but more compact. At the lower level the vein is split in two by about 6 inches of country. On either side of the veinstone the latter is slightly impregnated with cinnabar.

Though the barren material and the immediate walls are referred to as "country" the whole is so impregnated with secondary calcite and silica from percolating solutions as to be more correctly described as barren lodestuff.

From the strongest part of the vein at the point of test—from surface to about 10 feet—some highly-coloured veinstone has been extracted in sinking, the hues ranging from bright pink to purple. As conflicting views were

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entertained of the value of samples of this grade on view in Sydney prior to the recent inspection, tests were made in the Departmental Laboratory under Mr. J. C. H. Mingaye, F.I.C., F.C.S., of typical specimens of the highly-coloured and non-coloured veinstone, with the following results :—

No. 2,285—Coloured—.....Yield 0·92 per cent. of mercury.
„ 2,286—Non-coloured— „ 0·10 „ „

A further sample obtained by chipping the coloured blocks at surface yielded (No. 3,365) 0·825 per cent. of mercury.

From the ends and bottom of the shaft at 26 feet, 200 lb. (weighed) of ore were obtained by gadding out the full width of the exposed veins. This was broken small and carefully sampled in the usual way ; an assay (No. 3,363) of the test portion yielded less than 0·01 per cent. of mercury.

After selection of the average sample, 24 lb. of the remainder was weighed and reduced to one quarter, by rejecting everything destitute of cinnabar stains. An average of the reduced sample (No. 3,364) still gave a return of less than 0·01 per cent. of mercury.

The specific gravity of the "purple" ore, determined from a large piece, equalled 2·85 ; that of the "pink," 2·77.

A picked sample from the principal cinnabar make in the vein at 26 feet, about 2 inches thick, yielded (No. 3,368) mercury at the rate of 1·065 per cent.

The shaft at the present level is in poor average veinstone, though a very small proportion might be picked to about 1 per cent. It is apparent, from the superficial test made, that certain parts of the vein-stone contain about 1 per cent. of mercury, but the proportion of the latter to the bulk of the vein-stone cannot be estimated without further development.

The second deepest shaft (G on plan), locally known as Miller and Pollard's, was sunk at the site indicated by the writer as (C) in the first report, on the junction line of granite and diorite. The felsite previously mentioned has since been more definitely determined as an alteration product of the investing mineral solutions.

At the surface, evidence of a certain amount of leaching and redeposition was visible in the decomposed outcrop, which was horizontally banded with white and pink, representing alternate solution and impregnation at the various stages of weathering and decomposition. Similar conditions occur at the open cut (B on plan).

As previously recorded, samples (Nos. 4,057 and 4,058) from the outcrop yielded from 0·48 to 0·5 per cent. of mercury, whilst a sample of the less decomposed rock (No. 4,056) yielded 1·58 per cent. of mercury.

The present shaft was sunk 58 feet 6 inches a few feet south of the previous opening, cutting the lode material at some depth from the surface. At 46 feet, to which depth the water was lowered, the full width in the shaft is occupied by cinnabar-bearing lodestuff. The diorite in the centre of the exposed face is about 2 feet thick, and contains finely disseminated cinnabar throughout. On either side decomposed, or highly altered lode-stuff, passes gradually into hornblendic granite, cinnabar impregnating it so far as the limits of the shaft permit inspection. A sample taken from the full width exposed at 46 feet yielded (No. 3,375) 0·15 per cent. of mercury. Evidently the grade at this level is not equal to the lodestuff previously passed through, as the following assays show. Judging by the material in the shaft tip, which is indiscriminately mixed, sorting will be possible and satisfactory. A large sample of a fine-grained greenish rock (diorite?), crumbling on exposure, yielded (No. 3,369) 0·67 per cent. of mercury. A similar test of a pinkish felsitic rock, from the junction of the granite,

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weathering brown on exposure, yielded (No. 3,370) 0·805 per cent. A sample of the coarse-grained granite from the junction (No. 3,371) yielded 0·570 per cent.

Along the junction of the granite and diorite which is well defined, chalcedonic quartz occurs, with nests of stellate crystals of stibnite on its surfaces.

On dissolving a little black calcite from the main shaft (D), a mass of fine acicular crystals of stibnite remained. It is possible that mercury is associated with it, forming the mineral "Livingstonite," though no tests have yet been made.

The diorite dyke, as before stated, can be traced to the west right through M.L. 1, and it is possible, notwithstanding the apparent discrepancy in the strikes, that the vein-stone at O and P, near the Clarence River, agrees in more than resemblance with the dyke line.

Between G and E several shallow openings reveal a common class of material, though in places more chalcedonic. At M, a sample of decomposed impregnated rock, exposed at surface, yielded (No. 3,374) 0·06 per cent. of mercury.

Shaft E, the 20-feet shaft of the first report, has fallen in; hence no fresh developments are to be recorded here. Still further west, at R, the dyke has been exposed at an excavation; traces of cinnabar only are visible at this point.

B represents an entirely new discovery, where an open cut exposes a width of about 17 feet of rotten hornblende granite, lightly impregnated with cinnabar. The conditions of occurrence at this point indicate a certain amount of progressive leaching and redeposition of the cinnabar, in the horizontal, curving, and vertical seams determined by the shell-like weathering of the rock and the angles of the joint planes. It is noticeable that the principal deposition of the cinnabar is in these lines of soakage, though, not confined to them, as the mineral occurs in the rotten granite in the form of fine circular or semi-circular plates or stains exhibiting strong indications of secondary origin. It appears certain, however, that, as in shaft G, the granite will be found in depth to be impregnated with cinnabar from the original deposition.

The siliceous rock exposed in the cutting, which possesses the usual chalcedonic characteristics, probably represents the original line of fissuring and subsequent infiltration of heated mineralised waters from which percolation and impregnation of the enclosing granite ensued.

A test shaft and crosscut are needed at this site to determine the width and strike of this ore body, which at present are not definable. Until the unweathered rock is reached it would be hazardous to attempt an estimate of the value of this deposit. The extent of the surface impregnation is indicated by the result of a properly averaged sample of about 1½ ton of the material freshly extracted from the full width of the open cut, viz. (No. 3,366), mercury 0·035 per cent. An average sample of the seams and joint fillings in the exposed face of the open cut yielded (No. 3,367) mercury, 0·115 per cent.

Summary.

It will be seen by the aforegoing statement that whilst the quantity of cinnabar-bearing material in sight has been increased by further prospecting, the grade has not correspondingly improved. The line G to F will probably yield a workable quantity of ore, yielding from 0·5 to 1 per cent. of mercury. From the main shaft, D, and Doctor's Shaft, F, lesser quantities of similar

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grade will be obtainable. From B no ore approaching this grade is yet obtainable; whatever its prospects in depth, it cannot yet be taken into account. The question confronting the newly-formed company now is,—Can ore of the above grade be profitably worked under local conditions? Certainly, even lower grades are successfully operated on in Europe and Russia; but circumstances alter cases, and it is more than doubtful if the Yulgilbar deposits could be attacked on a commercial scale as they now appear. On the other hand, there is every reasonable inducement, as there is every need, for an adequate test to effectually decide their workableness or otherwise.

A little fine cinnabar occurs with gold in the bed of Sandy Creek, on the west side of Clarence River, close to the Yulgilbar Crossing. A slight amount of prospecting has been done in endeavouring to locate the matrix from which it is derived, and traces are reported in a rock somewhat similar to the vein rock at the main mines.

Queensland*.

The cinnabar country lies to the west of Kilkivan, between the heads of Wide Bay Creek and Kilkivan.

Several lodes are mentioned. One about 6 miles from the heads of Wide Bay Creek, and due west of the Black Snake Gold-mine, is described as of "brownish quartz"; and the central portion a conglomerate of broken-up particles of quartz cemented by deposition of silica from percolating waters, the pebbles being coated with small crystals of quartz. The country consists of micaceous and chloritic schists. The cinnabar occurs disseminated in the quartz, giving it a pinkish colour.

The Wolf Lode—about 1 foot thick—is composed chiefly of calcite, in which cinnabar occurs both in bunches and disseminated. The country being conglomerate, sandstone, and shales.

About 6 miles north-west of the Wolf Lode, the caps of several unprospected cinnabar lodes are reported.

About 1½ mile east of Messenger's, on King Bombi Creek, in altered sandstone and greywacke, is another lode, described as a gangue of calcite in the middle of a breccia of quartz and calcite; cinnabar and colours of gold being visible in the calcite.

Prospecting Lode.—Situated about 1 mile east of Messenger's, in coarse altered sandstone. Lode consists of a hard brown jasperoid quartz, stained with carbonates of copper. Cinnabar disseminated through the quartz.

Queensland Lode.—The Queensland claim of 80 acres—reported to contain three or four distinct lodes—of which the Queensland lode is the largest and richest, varying up to 7 feet wide in places, and averaging 4 to 5 per cent. of mercury from the dressed ore.

Mr. Rands states that 70 tons of ore yielded 6,000 lb. of mercury, with the roughest appliances for retorting and condensing the mercury. The lowest grade of lodestone yielded 1½ per cent., and the highest 23 per cent., whilst a small parcel of drift cinnabar yielded 60 per cent., the average yield being 3·8 per cent. from the lodestone.

Additional notes on these deposits, by the same authority, appear in the Annual Report of the Department of Mines Queensland for 1886, pp. 70, 71.

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* Report on the Geology and Mineral Resources of the Districts of Kilkivan and Black Snake. W. H. Rands, Assistant Government Geologist, 1886.

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The *Queensland Lode*, at 42 feet, is described as consisting of a small rich vein of cinnabar in quartz on the eastern side of foot-wall, then 8 inches of quartz and calcite with cinnabar, and another mass of veinstuff in hanging wall; lode divided by a horse of mullock. Country, altered conglomerate or agglomerate "probably of volcanic origin, as it is full of angular particles."

Wolf Lode.—Level driven 170 feet on lode, consisting of "sandstone and shale underlying a volcanic ash much decomposed, and containing large angular pebbles." Lode strikes north-east, averages 1 foot in thickness. Matrix contains more calcite than the Queensland lode.

"A cross-cut lower down the gully cuts several lodes or veins. At 19 feet, one of 1 foot in thickness of calcite; at 55 feet, a lode of 1 foot 2 inches wide showing good ore; at 119 feet is a vein of calcite which appears to be dipping towards some leaders at 145 feet, which contain cinnabar; and at 200 feet the Wolf Lode is cut 4 feet 2 inches wide, and contains a very good percentage of cinnabar.

"So far as the work has at present gone the prospects for the future of these mines are very encouraging."

In 1891 (Ann. Rept. Geol. Survey Queensland for 1891, p. 17), Mr. Rands reported on a discovery of alluvial cinnabar on Messrs. Mactaggarts' section No. 2,447, at Kilkivan.

"A number of lodes carrying rich cinnabar have been worked on a ridge which runs through the selection in the form of a crescent. These lodes carry patches of a very high grade cinnabar, running in shoots, and are situated in a coarse-grained granite; surrounding the granite is a much altered porphyritic rock.

"The alluvial cinnabar occurs in a flat heading down from perhaps the richest of these lodes—the Commotion Lode. The wash-dirt consists of a granite drift, with large pebbles of the altered porphyritic rock, and contains small water-worn pebbles of cinnabar throughout it, with occasional pieces of a large size, sometimes over 1 lb. in weight. It averages about 4 feet in thickness, and has been met with in three shafts over a distance of 9 chains.

"The reefs in this selection, from the beginning of the year up to the end of October, have yielded 1·5 tons of quicksilver from 28 tons of ore. The total yield of quicksilver from the district is 4·1 tons."

Victoria.

Native mercury and cinnabar occur at Silver Creek, a western tributary of the Jamieson River. The site was briefly reported on by Mr. R. L. Murray, F.G.S., late Government Geologist of Victoria, in the following terms: "The formation consists of dark Silurian slaty rocks, and the mercury occurs in bands of these extending over a width of about 12 feet, principally in or near small strings of quartz. Globules of mercury are obtainable by breaking up and washing the slate, and can be seen in the cavities of the quartz. I was also able to detect small patches of cinnabar or sulphide of mercury in the quartz. The quantity of the metal is, however, altogether too small to be payable; and there is no evidence justifying the hope that it will become more plentiful at greater depth, though sinking a short distance to settle the question would be advisable. So far the discovery can only be said to be of scientific interest."*

* Report on the country between Wood's Point and Jamieson. Dept. Mines Vic. for 1898, p. 3.

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The Jamieson Quicksilver Company was formed to work this deposit, and in the *Australian Mining Standard* of the 10th August, 1899, it was announced that "a first sale of quicksilver, the product of an Australian mine, was made on August 1st, when the Jamieson (V.) Quicksilver Company disposed of a quantity retorted from ore from their mine to the local United Gleeson and Sailor Bill's Company."

New Zealand.

The Ohaeawai cinnabar deposits in the Bay of Islands county, about 30 miles from the old township of Russell and 18 from Kawakawa, are the most important yet discovered in New Zealand. Though known as early as 1870, no attempt was made to work them until 1895, when an English syndicate began prospecting operations, under the supervision of Mr. André P. Griffiths, from whose paper on the subject the following notes are extracted* :—

"The Hot Springs, better known as Tuwhakino and Ngawha, around which the various quicksilver deposits are clustered, lie about 2 miles to the south-east of Omapere Lake. . . . .

"The face of the district, which at one time must have been the source of intense volcanic action and disturbance, is studded with old craters and extinct volcanoes. . . . .

"The country around the Hot Springs consists of a series of low, undulating, fern-clad hills. To the north-east and south-west these hills are mainly composed of fine blue limestones and firestones, which are covered by layers of varying thicknesses of 'green sand,' marly clays, and flints. All these rocks compose nearly the whole of the Tertiary Coal Measures of the island. . . . .

"These undulating hills form several crateriform hollows of varying diameters and depths, in which are found the Hot Springs and quicksilver deposits. . . . .

"The springs give off large quantities of sulphuretted hydrogen gas and occasionally a little steam. . . . .

"The deposits which have been formed by these springs consist essentially of beds of moderately hard brown and grey sandstones, or solidified siliceous mud, with layers of calcareous and siliceous sinter, through which the cinnabar has been deposited, together with native sulphur. They include also several layers of bituminous shale, containing an appreciable quantity of petroleum oil.

"There are, moreover, deposits of pyrites, with or without cinnabar, in some cases containing traces of gold and silver." . . . .

"The cinnabar occurs principally as lining small cavities and cracks in the solidified muds and green sand immediately surrounding the original fissures of the underlying basalt. Cinnabar is also found impregnating a fragmentary sinter, overlying the very fine muds or sandstone, but below the bituminous shale."

Mr. Griffiths records only one instance of the association of cinnabar and pyrites. Free mercury occurs only in very small quantities, apparently originating from decomposition of cinnabar.

The recent origin of the deposits is demonstrated by the evidences of active formation now in progress. Fine films of cinnabar are being deposited with

* The Ohaewai Quicksilver Deposits; by André P. Griffiths. Trans. New Zealand Inst. Mining Engineers, Second Session, 1898, ii, pp. 48–58.

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native sulphur around the small orifices, at the bottom of trenches made during the prospecting operations, by the hot gases and solutions evolved from below; also from the presence of cinnabar in Kauri gum and in the charred trunk of a partially embedded tree.

The richest deposits are described as being nearest to the hottest gas vents; hence, at a very shallow depth a temperature was reached sufficient to preclude mining operations. A bore-hole put down 104 feet ejected mud to a height of 60 feet, followed by boiling water with H_2S in solution.

In their origin and mode of formation these deposits resemble those of the Pacific Slope, California, and of Steamboat Springs in Nevada.

Mr. Griffiths adds that the "cinnabar of Ohaeawai is associated with calcite, chalcedonic quartz, marcassite, sulphur, and bituminous matter."

"It would seem that there is no doubt that, in the case of the Ohaeawai deposits, the cinnabar was precipitated from hot ascending solutions or vapours near the surface. The gases which escape from these springs are mostly sulphuretted hydrogen, steam, and carbonic dioxide, with, possibly, a little carburetted hydrogen."

The following New Zealand mercury localities are also noted in the paper quoted:—Tokomairiro and Russell (native mercury); cinnabar at Puhipuhi, Kerikeri, and the Bay of Islands generally in the North Island. At Waipori, in the province of Otago, in the South Island, quicksilver is found as cinnabar, mostly in the shape of rolled fragments of pure sulphide.

Small quantities of cinnabar as a pulverulent deposit lining the inside of cracks and small cavities of quartz, along the outcrop of the Big Tin Lode at Te Aroah, also on footwall side of lode.

Cinnabar also occurs near the head of the Kaueranga River, in the Thames district.

A further discovery is reported in the *Australian Mining Standard* of the 23rd November, 1899, in the Waitahuna Ranges, 12 miles from Berwick, and halfway between that place and Waipori. Drift cinnabar traced to a lode 16 inches wide, in which about 3 inches of cinnabar occurs on the hanging wall.

THE TUWAKINO CINNABAR MINES, (OHAEAWAI), NEW ZEALAND, SITUATED ABOUT 20 MILES FROM THE BAY OF ISLANDS, AND 12 FROM KAWA KAWA; COMPILED FROM NOTES FURNISHED BY MR. S. L. BENSUSAN, O'CONNELL-STREET, SYDNEY.

"The Tuwakino Mercury deposits occur in a freehold of 465 acres, lying to the north-west of the site of the English syndicate's operations at Ohaeawai."

"The cinnabar is brought from below by thermal action and deposited within the crater of a moribund volcano, in the last stage of solfataric activity. The watershed formed by the margin of the crater concentrates the rainfall and surface drainage into a pool at the bottom, about 60 feet in diameter. This water penetrating to considerable depths becomes greatly heated, and thus affords a ready means of diffusion of the increased temperature to the surface. For some distance round the margin of the pool similar sodden, heated conditions exist. Hitherto all attempts to mine round the pool beyond a depth of 10 or 15 feet were baffled by the sodden ground and heated water, and fumes of sulphuretted hydrogen, sulphurous, and carbonic acid gases.

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"All round the pool for a considerable distance cinnabar is obtainable in every spadeful of earth. The problem, therefore, is how to overcome the difficulties enumerated, which have arrested operations in the past. After two visits to the locality a solution presented itself to the writer in a system of drainage, which the natural configuration of the country renders feasible. By draining the crater of its subterraneously heated water, the cause of the abnormal heating of the surface would be removed, and workable depths could be reached in direct proportion to the level of the drainage. Starting from the crater an irregular line of fissure extends for a considerable distance in a south-easterly direction, and at intervals along this line cinnabar has been met with, but no defined run of it.

"A few years ago, in company with my son, Mr. E. Bensusan, A.R.S.M., an examination and superficial test was made of the deposit. Both cinnabar and native mercury were obtained in several shallow holes round the pool, heat and fumes preventing more adequate testing.

"A second visit with another son—Mr. A. J. Bensusan, A.R.S.M.—was more successful, and suggested the solution already mentioned. By means of a small creek, which affords a natural outlet for the surplus water of the pool, we succeeded in lowering the standard level from 2½ to 3 feet. After allowing the drainage to continue for a few days, a hole was sunk a few feet from the pool to a depth which could not have been reached without the drainage effected. Here splendid prospects of cinnabar were obtained, from massive lumps to pulverulent material.

"Continuing sinking, at a moderate depth the ground became softer and hotter, and water oozed in; further operations had, therefore, to be abandoned."

"The result of this superficial test indicates the possibility of turning this valuable deposit to account. By means of a trench round the sides of the crater above the pool all surface drainage could be diverted to the overflow channel or creek, whilst a pump of moderate power could lower the accumulated water in the pool, and thus allow the surrounding cinnabar-bearing ground to drain and cool."

"The deposit was visited some years ago by Mr. Peake, A.R.S.M., who obtained a quantity of the cinnabar ore and conveyed it to London, where, subsequently, Mr. Snelus, of the Royal School of Mines, assayed it for a return of 55 per cent. mercury."

"As regards the relative richness of this deposit compared with the known cinnabar mines of the world, which, with the exception of Almaden and New Almaden, average less than 1 per cent. of mercury, all the assay returns of properly-taken samples from Tuwakino, so far as obtainable under the circumstances, ranged from ¼ to 6 per cent."

"One of the principal items of expenditure, particularly in connection with high-temperature cinnabar mines like the one in question, is securing and maintaining powerful ventilating machinery, an item capable of considerable reduction at Tuwakino by utilization of a waterfall of about 200 feet within the property itself. This fall is believed to be sufficient for generating all power requisite for developing the property, ventilation, electric lighting, &c."

"On the south-east of this property, following the line of fissure referred to, a plant was erected to treat the cinnabar found on that ground, but success does not appear to have attended the work undertaken. I do not think that the plant erected was adapted for the work. Furnaces taking charges of 1 cwt. are out of date, the most economical now used take 50-ton charges, or 1,000 times this quantity; the expense, too, is about a fifth or a sixth."

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"The cost of treatment, recorded as 16s. per ton, is out of all reason. In my paper on the mode of occurrence and metallurgy of quicksilver, published in the *Town and Country Journal*, January, 1870, it is shown that in Germany they treat at a profit an ore yielding $\frac{1}{8}$ per cent.—value 6s."

"Some years since Messrs. Cox and Seaver reported on this property, and referring to a report of Mr. J. A. Phillips on a quicksilver mine in South America worked under similar conditions as to heat and moisture, stated that in one of the mines there they work levels 104, 157, 210, 260, and 310 feet from surface; that the heat of freshly-cut rock was often too great to be borne by the naked hand, but by a complete system of ventilation the mine was able to be worked successfully."

"As far as the cinnabar deposits at Ohaeawai are concerned, certainly those round the White Lake, I can see no reason why they may not be worked from open quarry, using modern, up to date furnaces of 50 tons capacity, when the shifting of the stuff and furnacing would pay with as small a yield as in Germany, or an eighth of a per cent. Probably it would pay to import German workmen, who know their business, and give them an interest in the results."

[Plates.]

Sydney: William Applegate Gullick, Government Printer.—1900.

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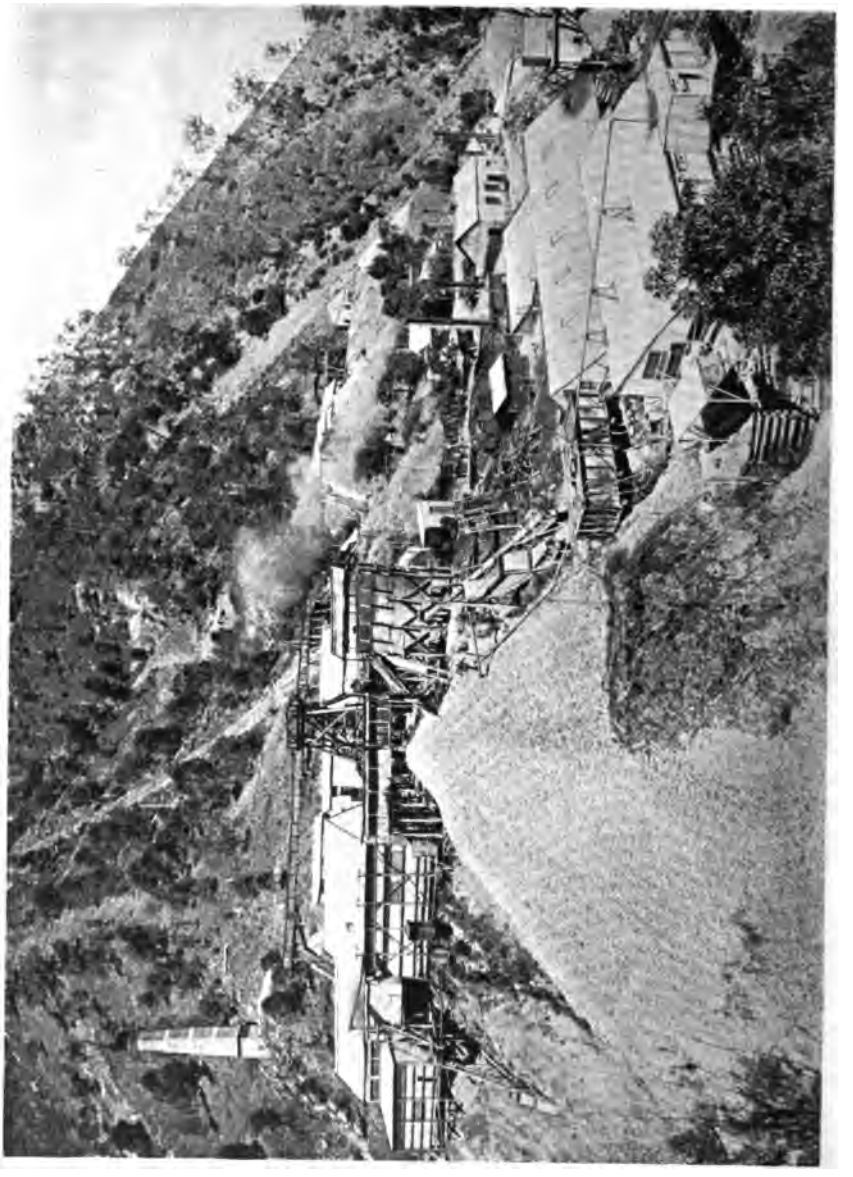

BAKER'S CREEK BATTERY, FROM THE WEST.

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NEW SOUTH WALES.

DEPARTMENT OF MINES AND AGRICULTURE.

GEOLOGICAL SURVEY.

E. F. PITTMAN, A.R.S.M., Government Geologist.

MINERAL RESOURCES.

No. 8.

REPORT

ON THE

HILLGROVE GOLD-FIELD.

BY

E. C. ANDREWS, B.A.,

GEOLOGICAL SURVEYOR.

1900.

SYDNEY: WILLIAM APPLEGATE GULLICK, GOVERNMENT PRINTER.

1900.

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LETTER OF TRANSMITTAL.

Geological Survey Branch, Department of Mines,
Sydney, 4 June, 1900.

Sir,

I have the honor to transmit for publication **Report No. 8** of the Mineral Resources Series, on the Hillgrove Gold-field, by Mr. E. C. Andrews, B.A., Geological Surveyor.

The geological survey of a considerable portion of this field was made by Mr. J. A. Watt, late Geological Surveyor; that gentleman, however, resigned his position on the staff at the end of March, 1899, and the survey has been completed by Mr. Andrews, who also examined the underground workings of the mines, and has furnished the accompanying report.

Hillgrove is one of the most important of the New South Wales gold-fields discovered in recent years, and it is of special interest on account of the occurrence there of lodes containing ores of both antimony and tungsten, associated with gold. The recovery of gold and antimony, from ores containing the two metals in conjunction, has always been a troublesome metallurgical problem, and in Hillgrove we have a field which offers a valuable opportunity to anyone who can devise a workable process for separating and saving the two metals. The scheelite deposits have recently been proved to be of considerable importance also, and it is hoped that the publication of this brochure may, by drawing the attention of the public to these interesting mineral deposits, have the effect of reviving the mining industry of the district.

I have, &c.,
EDWARD F. PITTMAN,
Government Geologist.

The Under Secretary for Mines.

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SYNOPSIS OF CONTENTS.

1. Introduction.

2. History of the Field.

3. Previous Literature dealing with the Hillgrove Area.

4. Physical Geography.

(*a*) Drainage system. (*b*) General appearance of tablelands. (*c*) Ravines. (*d*) Scenic features. (*e*) Meteorology. (*f*) Influence of the ravines on the mining industry.

5 Geology.

Various rocks of field. Chronological order of geological events. (*a*) Sedimentary rocks. (*b*) Eruptive rocks—First granite intrusion; second granite intrusion; third granite intrusion; fourth and latest acid intrusion; dykes; slopes of Hillgrove granite bosses. (*c*) Metamorphism—The sedimentaty rocks; the "kicking" slate; the eruptive rocks. (*d*) The Lodes—Direction of strike: origin; later movements; cross courses; occurrence and nature of ores. (*e*) Geological events subsequent to the formation of lodes—Metamorphism; erosion of Palæozoic rocks; old river beds; Tertiary basalts; erosion of rocks since Pliocene (?) times to form present ravines. (*f*) Petrological notes on some Hillgrove rocks.

6. Life of the Reefs at the Lower Levels.

7. Descriptions of Mining Properties.

(*a*) The Golden Gate Reefs. (*b*) The Proprietary Reefs. (*c*) The Hopetoun Reefs. (*d*) The Eleanora Reef. (*e*) The Garibaldi Property. (*f*) The Cosmopolitan Reefs. (*g*) The Carrington Reefs. (*h*) The Sunlight Reef. (*i*) West Sunlight Mine. (*j*) Baker's Creek Reefs. (*k*) The Consols Reefs. (*l*) Starlight Reef. (*m*) Sandon Electric Light and Power Company. (*n*) Paradise and No. 9 Antimony Lodes. (*o*) Murgatroyd's Tunnel. (*p*) Minor Properties—The Baal Gammon Reef; Trimm's Tunnel; Mount Carrington Gold-mining Company; Beiber's Tunnel; Keye's Scheelite; Maddrick's Scheelite; Brackin's Spur; Beck's Antimony Lode.

Description of Plates.

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Report on the Hillgrove Goldfield.

INTRODUCTION.

THE immediate object of this report is to furnish a fairly clear conception of the field to the mining public by brief reference to the succinct points in the historical, topographical, geological, and economic mining features of the area under consideration. A map and sections of the field have been prepared. On the map are shown the relative extents of the various derivative and eruptive rocks of the Hillgrove area, as also the nature of their junctions one with the other. Thus the practical miner, knowing the Hillgrove area well, may take this as a guide wherewith to recognise similar rocks in contiguous areas. As an example, everyone using the Baker's Creek Tramline must have observed the great bluffs of rock and attendant long talus slopes exactly opposite to them in their progress downwards. With very few exceptions the miners of the field have assured me that it is a hardened slate, despite all assurances to the contrary. When it is known that this fine-grained rock is intrusive into the older rocks that contained the lodes, it is readily seen what a vanishing quantity the hope becomes of finding here the continuations of such reefs as the "Big" and "Little" lodes, which, however, would be quite feasible were the rock under consideration a belt of slate, as believed by the majority of men on the field.

The country is admittedly difficult to conduct geological observations in accurately. This is due in part to the highly metamorphosed character of many belts of the sedimentary formations, rendering it difficult to discriminate between fine-grained eruptive rocks and some of the more indurated and silicious slates. As an example may be quoted the curious belt of rocks running north and south through the Catholic School grounds, and ending southwards in a prominent bluff of rocks, overlooking for miles the valley of Baker's Creek, and known as Whittaker's Spur (Plate II). At first glance this might be mistaken for a granitic rock, although even a cursory inspection of its weathering reveals its sedimentary nature. Another and more difficult case occurs on the Metz side, on the flat ground west of Petersen's and Bewley's scheelite lodes. Here two long tongues of slate alternate with as many tongues of fine granite, and, to the untrained eye, the two are indistinguishable. Many have pronounced it all altered slate country. In reality, as seen on the map, the slate occupies the smaller area. Possibly the Four-mile offers the most bewildering spectacle, where granitic rocks in places succeed in palming themselves off as sandstones and slates, and altered bedded rocks conceal almost every trace of their derivative origin.

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Special features of the report, exclusive of the main idea of the work, consist of notes on the numerous dykes which intersect the sedimentary formations; the prevailing types of lode formations; the antimony and scheelite lodes; descriptions of the machinery; and the methods of travelling on the steep hill sides.

As a starting point, and a basis of work, I had the partially completed map of Mr. J. A. Watt, M.A., B.Sc., formerly one of the Geological Surveyors in this Department. Having made use of his main east and west line of junction of the eruptive and sedimentary rocks, I preferred to undertake most of the work *de novo*, as it was necessary to get well acquainted with the surface before attempting the underground survey. With one or two exceptions, our boundary lines, &c., are fairly coincident. The various junctions of eruptive and sedimentary rocks to the east in the difficult country of the Four-mile Creek, and those also to the south of Bakers' Creek, were, previous to my reconnaissance, a blank page. For these I am alone responsible, as also for the squaring-up of the map in all directions. The broken character of the country, the veiling of the various lines of junction under masks of shingle, and the great metamorphism of the rocks, necessitated a far greater expenditure of time than would be required for the examination of ordinary country. Besides these, the absence of landmarks was felt, and some of the junctions are, at best, only approximately true. I was enabled to secure a fairly good series of photographic negatives, dealing with subjects of mining and geological interest. In all departments of the work I have to acknowledge the great assistance of Mr. M. Morrison, Field Assistant, who accompanied me throughout the trip. Especially valuable was his aid in dealing with the difficulties that beset us in attempting to make out the chronological succession of the eruptive rocks.

I desire to here cordially thank Mr. G. Smith, one of the directors of Baker's Creek Gold-mining Co., Mr. Thomas and Mr. M'Namara, of the West Sunlight Mine, for notes on the general history of the field; Mr. H. M. Porter, Manager of the Proprietary Mine; Mr. S. McGeorge, Manager for Baker's Creek Gold-mining Co.; Mr. R. Sharp, Manager of the Eleanora Mine; Mr. F. Cape, Manager of the Sunlight Mine; Mr. S. Mills, Manager of the Consols Mine; Mr. T. Snow, of the Golden Gate Mine; Mr. A. Nicholson, of the Starlight Mine; Mr. J. Fuller and Mr. S. Sullings, for permission to make tracings of their mine plans, for information concerning the gold yields of their respective claims, and for notes on the history of their respective mining properties; also, all the underground managers and other officials, from whom, without exception, I received every assistance in the way of mine measurements, and other items of interest in the underground workings.

2. HISTORY OF THE FIELD.

Three decades ago the population of Hillgrove was confined to a few stragglers on the Metz side, who divided their time between helping at the local station during the shearing season and occasional prospecting along Baker's Creek bed. That was before the discovery of gold and antimony in payable quantities. To-day some 3,000 people draw their means of livelihood, directly or indirectly, from the product of the reefs; and Wyalong, a field of still later growth, is to-day the only field in New South Wales ahead of it in gold returns; while so far is the latest report of Baker's Creek Co. from sounding a note of decadence, that the final fortnightly clean-up for the half-year totalled 1,285 oz. of smelted gold.

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To face page 6.

WHITTAKER'S SPUR, SEEN FROM THE SOUTH.

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At first all the difficulties attendant on pioneer mining in broken country had to be encountered; horses, bullocks, and men dragged loads of ore while they climbed the steep sidelings—so steep sometimes that bullocks have been dragged back by their loads; landslips were common in the treacherous ground at Swamp Creek; dollies were the only appliances available for extracting the gold; and after tremendous expenditure of energy in hauling the ore up the gorge slopes, long monotonous journeys had to be undertaken by teamsters over execrable roads to Grafton or Tamworth before their loads could be delivered over to steamers or trains. Batteries and good tracks came slowly at first, but with the advent of payable ore conditions were altered. Tramways were constructed on the hill sides, large batteries were erected to facilitate crushing operations, and at the present time the Sandon Electric Light and Power Co. are preparing to drive the machinery and light the mines by electricity.

Having thus glanced generally at the history of the field, it is proposed to note briefly the chronological order of the more important events constituting the principal factors in the making of the Hillgrove of to-day.

Haversbed Bros. and Thomas led the way in 1877 by finding an antimony lode quite close to, and south of, the present Hopetoun Reefs. A parcel of 4 tons 17 cwt. was obtained by them from the outcrop, carted to Grafton, and thence despatched to England; £17 15s. was paid for the consignment. Negotiations were then entered into by this party with Hudson and Co., of Sydney, for the purpose of erecting antimony smelting works.

About the same time Campbell Bros. mined for antimony on the spur now named after them, and lying a little north and west of Baker's Creek battery. Moore, Speare, and McBean followed by taking up an 80-acre block on the Southern side of this spur, and afterwards took up Portion 58. These portions were taken up under the now obsolete "mineral conditional purchase" conditions, and worked for antimony. At first the mining was performed by tributors, but the owners found these latter shooting much of the ore won down the hill slopes, so as to pick it up at their leisure in the creek below. To prevent this loss to themselves, Moore's party took up an additional portion of 80 acres, known as M.C.P. 110.

In 1878, Brackin, Daly, and Elliott found a long line of reef containing antimony. This was afterwards worked as the Isabella lode. It was discovered on the Hillgrove side of the gully, whereas the previous finds had occurred on the Metz slope. Another event was the discovery of the Paradise and No. 9 lodes, two antimony reefs, which after keeping company for some distance diverged from their original course, and struck out nearly at right-angles to each other. The continuations of these two lodes were found in the flat country above the gorge, and from them one parcel of 10 tons was extracted.

Another antimony lode was worked on Brackin's Spur, a prominent landmark near the junction of the Baker's and Four-mile Creeks. This lode turned out some very good ore. Junce and Kerseller, acting for an Armidale syndicate, opened up antimony smelting works near the head of Swamp Creek and treated the various antimony ores of the field.

Up to this time there had been no thought of gold, and, even when specks of the precious metal were discovered in the Garibaldi Reef, its significance was not appreciated, owing to the difficulty experienced in extracting gold from an antimony admixture. The first speck seen on the field occurred in No. 2 shaft of the Isabella line of reef, now known as the Garibaldi Shaft. Aaron Smith is credited with the observation.

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After the Eleanora and Garibaldi had been worked for some time, the attention of the companies prospecting them was turned to the winning of gold, and in November, 1881, Mr. G. Smith was appointed by an Armidale syndicate to manage the Garibaldi property. Supposed payable gold was then found at the Eleanora, and a party of six from Armidale, exclusive of Brackin, Daly, and Elliott (who, as discoverers of the lode, were included) formed a company and took up a gold lease of 20 acres. Four tons were made up for the first parcel and sent to Sydney. Quick bought these on assay and shipped them to England. The return was 7 oz. of gold to the ton. 89 tons in all were sent away. At the end of 1882 and beginning of 1883 the Eleanora was put into a company of 12,000 shares. A 10-head battery, brought over from Stawell, in Victoria, was erected by Scoular. The battery was then increased to 25-head, and to anticipate slightly, G. Smith, who had bought back into the company, made preparations for the erection of 70-head of stampers in 1892, and which, in 1899, were utilised for the first time.

The Garibaldi Reef was still worked for antimony. In 1882 came a revival in the demand for this metal, and a consequent rise in price. In 1882 it brought £7 per ton in Armidale. Hargreaves, the owner of Hillgrove Station, had been working an antimony claim on the top of the Swamp Creek Falls. This was known as the continuation of the Paradise and No. 9 lodes. In 1885 he leased the claim to tributors, and imposed a royalty of £1 per ton on all the ore won. 141 tons of antimony were taken out of this reef in 1885 and part of 1886. Besides this amount, Hargreaves had previously extracted 91 tons. A slump occurring in the price of antimony, the value of crude ore going down to £4 10s. per ton, the lodes were prospected for gold. From these lodes, at various times, about 2,000 tons of crude antimony have been extracted, 500 tons from the top and 1,500 tons from the creek sides. The ore was carted up the gully at first by bullocks (Plate III), and afterwards drawn by trams.

In the middle of 1886 the Carrington lode, occurring in the granite north of the Eleanora, and worked previously for antimony, was opened up for gold. A sample of 2 tons was forwarded to the Sydney Mint. The total return was 5 oz. 13½ dwt. In the same year this lode was inspected by Neilds of Adelaide and Deitz of Temora. It was then formed into a company and prospected again.

In 1887 came the real opening up of the gold-bearing reefs of the district, when the Little, Big, Middle, and Baalgammon veins were discovered; when the lodes worked by Moore, Speare, and McBean, on the west side of the Baker's Creek gorge, were found to contain gold, and when the Cosmopolitan, Hopetoun, Starlight, and Centennial claims were taken up for gold-mining purposes.

In the early part of that year, G. Smith was invited by J. Elliott, G. Phillips, T. Asche, and N. O'Donnell to inspect something which they had unearthed on the Metz side of the creek. Accordingly, Smith started from Hillgrove to cross the gully, intending on the way to prospect the creek bed for himself. While crossing the stream he lighted on a piece of quartz carrying gold. Fixing the spot, he determined to trace the gold to its source on his return. A search led him to the outcrop of the Big Reef, where he found a strong body of stone, 4 ft. wide, containing much fine gold, the metal standing out above the weathered reef. He brought up a large piece of the stone to the town flat and dollied it there. So incredulous, however, were the local people that it required some little persuasion to arouse sufficient enthusiasm in a party from Armidale to bear the expense of the application and

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survey of the lease of 15 acres. During the pegging out, the surveyor employed discovered a piece of quartz containing gold near the south boundary line. Smith traced this to a lode running parallel to the boundary throughout the length of the ground. Thus unwittingly was the "Little" or "Smith's" line of reef pegged in. Afterwards it was ascertained that the last-discovered reef underlay into the surveyed portion.

It was on the 27th March, 1887, that this 15-acre block was applied for. The finding of gold near the creek, however, was not absolutely a surprise, as an adjoining lode, named Hill's Reef, had yielded gold four years before. The inception of gold-mining operations on the Big and Little Reefs was attended with astonishing results. From 2 tons 6 cwt. taken from an open cut, the Sydney Mint obtained 105 oz. 9 dwt. by crushing. A large dolly with spring pole was next put up, and with this primitive battery, G. Smith and brother, two Millers, with two men on wages dollied out £2,500 worth of gold in four months. The property had been known as the "Four Brothers' Mine," but the name gradually fell into disuse. The first reef discovered was christened the "Big Reef," and the erstwhile "Little Reef" was renamed "Smith's Reef." A meeting of the shareholders offered one fifth share for a 5-head battery. W. B. Neild accepted the offer. A company of 100,000 shares, paid up to 17s. 6d., was floated, since which time the company have paid fifty dividends, amounting to £267,500. This mine has crushed 117,635 tons of ore for 188,812 oz. of gold (exclusive of that contained in the concentrates) since it started mining operations. Owing to its persistent success it has been the greatest factor in the stability of the mining industry at Hillgrove.

To return to the Sunlight, the finding of which slightly anteceded that of its richer neighbour, the Baker's Creek property. This was the find which Smith was requested by Elliott and O'Donnell to inspect. The discovery was made on Moore, Speare, and McBean's M.C.P. 109, and the reef previously worked for antimony. Two men, named A. Argles and J. M. Dalzell, representing themselves as capitalists, had just arrived from Sydney to examine a new find called the "Root Hog," situate to the north of the Sunlight, and now worked as the Hopetoun. Elliot and Party entered into an agreement with Argles and Dalzell concerning the Sunlight, as the latter considered the land to belong to the Crown. Moore, Speare, and McBean contended that the land was theirs, while Elliott's party pegged out and claimed to hold it under miners' rights. Argles and Dalzell, meanwhile, recognising the claims of Moore and Party, leased block 110 from them, while Elliott and O'Donnell contested the point, and thus rose a series of litigations, extending over two years, at the end of which period, Moore and Party were left undisputed owners of blocks 58, 109, and 110.

The total amount of gold won from the Sunlight reef since 1892 is 36,873 oz. 6 dwt., and from the West Sunlight since 1894 is 19,000 oz. These amounts are exclusive of gold contained in the concentrates, and only represent a portion of the actual gold yield, as the mines have been worked since 1887 and 1888.

The best of the gold deposits contained in the granite lie in that belt of country occupying the western slope of the gorge north of Baker's Creek property. The first claims pegged out included the "Root Hog," taken up in 1897. These were then formed into the properties known as the Hopetouns, and taken up by a Victorian company in 100,000 £1 shares.

In the same year (1887) that the reefs of the Baker's Creek property were discovered, Thomas pegged out, in the coarse granite to the north of the slate belt, a portion containing certain reefs, which appeared to him to lie on the same line as the Eleanora. The property was taken up as the North and

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South Cosmopolitan, and worked for gold. Mining for the latter was soon discontinued in favour of antimony mining, as gold was scarce, but antimony very plentiful. Afterwards the land lay idle till some three years ago, when Thomas, Hay, and Parr pegged out afresh a part of the original lease, amounting to 2 acres.

Last July the Cosmopolitan and Carrington were amalgamated into "The Hillgrove United" by Fuller and Robinson. From the Cosmopolitan Reef, for the past two years, crushings have yielded 1 oz. to 27 dwt. of gold per ton of stone; 20 tons last year were crushed for 23 oz. 13 dwt. For these figures I am indebted to Mr. Fuller, of Hillgrove.

Some little time after the commencement of mining operations at Baker's Creek, "The Consols" Company took up a lease to enable them to work the southern extension of the Middle Reef and the north-west continuations of the Little and Baalgammon lines.

Among the more determined efforts to prove the north and south continuations of the Big and Little Reefs may be mentioned that of the Baker's Creek Gold-mining Company South, who drove two tunnels south of the Baker's Creek Company in a N.N.E. direction. The main tunnel has since been carried to a distance of 2,054 feet into the hill by the present Proprietary Company. Then, on portion 176, the Mount Carrington Gold-mining Company drove a tunnel into the hill 500 feet; but, after encountering a granitic dyke 10 feet wide, the idea was abandoned. To the north, Petersen and Party, Elliot and Party, as well as others, have prospected in vain; in fact, the whole of the later intrusive granitic mass to the north and west of Baker's Creek Company's workings has been pegged out and prospected, the men considering the fine-grained mass to be an indurated slate. The exceedingly rough country to the south-east—a tract pierced with dykes—has also been largely prospected.

Another line of reef that has been searched for beyond its present limits is the Sunlight. The West Sunlight Company, with their double lode, almost undoubtedly have the western prolongation; while Trimms and Murgatroyd, searching in the broken country to the east, claim to have hit the reef also.

The laying down of light tramways facilitated mining operations for such mines as the Baker's Creek, Sunlight and West Sunlight, Hopetoun, Cosmopolitan, and Carrington, all of which are situate in the gorge. The Baker's Creek Company led the way in 1889, and then followed in order the Hopetoun, the Sunlight, the Carrington, and West Sunlight.

Until telephones established communication between the top and bottom of the tramline, the Inspector of Mines would allow no passenger traffic.

The finding of high-grade scheelite near the town in the coarse granite is interesting, inasmuch as, so far, very few similar occurrences have been reported from New South Wales. The ore is confined to small lenticular patches in veins. The principal suppliers of the mineral are Keyes and Party, Maddricks and Party, The Hopetoun, and Wade's Party, near Brackin's Spur. Over 70 tons of scheelite were put into the market for the year ending December, 1899. Most of the ore was of good quality, varying from 50 per cent. to 60 per cent. of tungstic acid. Ten shillings per unit was paid for ore over 60 per cent. Keyes and Party, from two blocks, supplied 20 tons; Maddricks and Party, about 15 tons; Snow and Son, about 15 tons; Willmott and Company, about 20 tons. Most of this has been won during the half year ending December, 1899.

At present the Garibaldi, Eleanora, West Sunlight, and Golden Gate are not working, although the West Sunlight is expected to resume operations in February, 1900.

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Summary.

1877.—Finding of antimony in quantity at Hillgrove. Working of the Sunlight for antimony.

1878.—Brackin, Daly, and Elliot found Eleanora Reef (antimony). Claimed Government reward.

1881.—Gold found in Garibaldi.

1882.—Revival in price of antimony, giving the mining of this material an impetus. Eleanora formed into company of 12,000 shares.

1883.—Hill's Reef discovered and worked for gold. Ten-head battery for the Eleanora brought over from Stawell.

1886.—Carrington Mine discovered.

1887—Gold discovered in Sunlight Reef. G. Smith discovers Big Reef. Little and Middle Reefs opened up. Hopetoun discovered. Cosmopolitan Reefs pegged out. Sydney Mint crushed 2 tons 7 cwt. of stone from Big and Little Reefs for 45 oz. 17 dwt. per ton. Smith and party dollied out £2,500 worth of gold in four months.

1888.—Baker's Creek put up 10 head of stampers.

1892.—Baker's Creek increased crushing plant to 40 head of stampers.

1898.—Baker's Creek and Sunlight Reefs working with 40 head of stampers, Consols with 15 head, and West Sunlight with 20 head.

1899.—Eleanora increased battery to 70 head of stampers.

Gold Returns (exclusive of Concentrates).

Dates.	Oz. of smelted gold. oz.	dwt.	gr.
Eleanora, July, 1892, to Dec., 1899	31,477	11	3
Consols, Sept., 1897, to July, 1899	3,550	12	0
Baker's Creek (total), March, 1887, to Dec., 1899	188,812	0	0
Sunlight, Jan., 1892, to Dec., 1899	36,873	6	12
West Sunlight, Jan., 1894, to July, 1899 ...	19,000	11	0
Garibaldi...	Not known		
Golden Gate	2,100	7	0

Baker's Creek paid fiftieth dividend. 70 to 80 tons of high-grade scheelite won from lenticular patches in coarse granite.

3. PREVIOUS LITERATURE BEARING ON THE SUBJECT OF MINING AT HILLGROVE.

(*a*) In the Annual Report of the Department of Mines for 1883, Mr. C. S. Wilkinson, late Government Geologist, has a report on "The occurrence of Gold and Antimony Lodes at Hillgrove."

(*b*) Mr. J. E. Carne, F.G.S., Geological Surveyor, mentions the presence of scheelite in this locality in his pamphlet entitled "The occurrence of Tungsten Ores in New South Wales," published as No. 2 of the "Mineral Resources" series of this Department.

Various reports by the Inspectors of Mines and Wardens may be found in the Annual Reports for 1889, 1890, 1895, and 1898.

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4. PHYSICAL GEOGRAPHY.

(*a*) Drainage system. (*b*) Topography. (*c*) Ravines. (*d*) Scenic features. (*e*) Meteorology. (*f*) Influence of the ravines on mining industry.

(*a*) Drainage System.

Baker's Creek and the Gara River, the main drainage channels of the Hillgrove area, belong to the eastern or coastal system of rivers, their united streams forming one of the head waters of the Macleay River.

(*b*) Topography.

To one approaching Hillgrove from the west the general effect produced is that of evenly undulating country, with isolated and rounded hill masses rising above the gentle curves of the granite downs. Here and there late basalt outflows have produced extensive flats, and on these grass grows more luxuriantly than on the poorer contiguous granite areas. Clusters of curiously-weathered granite tors are of frequent occurrence; these, in silhouette, at times are grotesquely suggestive of animal and human outlines. The continuity of the granite plateau is broken, however, at the town itself, where a general east and west line of granite and slate junction occurs. This is the signal for a marked change in the topographical features of the district. The creeks, which have flowed through the table-land in broad and shallow beds, precipitate themselves over great ledges of rock nearly 1,000 feet in height. Several natural trenches, the outward and visible sign of the eroding waters, have been deeply cut into the slate and granite plateau. These are disposed in, approximately, a north and south direction, and contain, throughout their length, a marvellous wealth of rugged slope and precipice. In the vicinity of the town four such cañons may be crossed in an east and west traverse of two or three miles. Near the mines, Baker's Creek ravine is 1,500 feet deep, while a few miles lower down, where beds of soft black slate occur, the steep escarpments rise 2,500 feet above the creek-bed. Where the granite has been the rock attacked by the denuding influences, the gully sides are generally rough, and show large rounded blocks resting upon cuboidally-jointed rock-masses. At the heads of Baker's, Swamp, and the Four-mile Creeks the sides are quite precipitous, varying from 600 to 1,000 feet in height (Plate III).

(*d*) Scenic Features.

The scenic effects are at times weird and grotesque. In the granite country rectangularly-jointed masses simulate piles of masonry. Generally tall, ribbed, precipitous bluffs obtain in the slate country (Plate III). In Swamp Creek a great bluff of slate occurs, almost 1,000 feet in height, and exhibits bedding or joint planes bent almost into a semicircle. Sometimes long, narrow belts of slate, determined in shape by the cleavage, creep across the valleys. In places these tongues and solitary needles of indurated slate reach skywards for hundreds of feet. The sides of the slopes are barren as a rule, and lack both that warmth of colour so frequently seen on the sandstone bluffs of the New South Wales gorges and the dense vegetation that swarms at the bases of ravines generally.

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To face page 12

SLATE AND GRANITE JUNCTION, HEAD OF SWAMP CREEK.

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(*e*) Meteorology.

The altitude of Hillgrove township is 3,150 feet above sea-level, and the average rainfall is 40 or 41 inches per annum. Severe frosts occur in winter, which have a tendency to split the rocks, while during the summer the sun glows fiercely on the unprotected sides of the gorges. Very high winds desolate the plateau at times. One during my stay in November uprooted scores of trees, and shifted huge stones that tore up the mountain tracks as they darted down the gully sides. Thus, besides the transporting effect of water, the power of the wind and the alternations of heat and cold must not be overlooked as factors in the carving out of these ravines.

Severe floods are at times experienced. In 1893 a rush of water moved an angular granite block of forty tons some two chains lower down the creek, and this on fairly level ground.

(*f*) Influence of Ravines on the Mining Industry.

The commercial significance of these hill slopes with respect to the mining industry at Hillgrove will be seen at once :—

(*a*) As a source of expense.—In the need of costly tramways to expedite conveyance of material up and down the slopes, where beasts of burden would be almost useless ; in the discounting in value of minor mineral deposits situate on the slopes of the gorges, owing to cost of haulage and element of danger involved in coping with the numerous landslips which occur, particularly in the antimony area of the Swamp Creek.

(*b*) As a source of gain.—As a set-off to the loss entailed in travelling and hauling on the steep sidelings may be mentioned the power obtained by water conserved in dams situate on the table-land, and conveyed down the slopes in pipes ; and the facility with which some of the reefs may be won by tunnelling into the hill from the gully sides.

5. GEOLOGY.

Various rocks of the field. Chronological order of geological events. (*a*) Sedimentary rocks. (*b*) Eruptive rocks—First granite intrusion, second granite intrusion, third intrusion, fourth and latest intrusion ; dykes. The slopes of granite bosses. (*c*) Metamorphism ; the sedimentary rocks ; the "kicking" slate ; the eruptive rocks. (*d*) The lodes—Direction of strike ; origin ; later movements ; cross courses ; occurrence and nature of ores. (*e*) Geological events subsequent to the formation of lodes—Metamorphism ; erosion ; old river beds ; Tertiary basalts ; erosion of rocks to form present ravines. (*f*) Petrological notes on the Hillgrove rocks.

Geology.

Broadly defined, the geology of the field consists of a series of fine sedimentary rocks, broken into and altered by several granite masses, and by dykes of granitic origin. On the eroded portions of these ancient masses lie quartz pebble drifts covered by basalt flows.

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Chronological Order of Geological Events.

In the present state of our knowledge, it would be premature to insist on any definite order of succession among the various strata and subsequent eruptive rocks.

The slates and quartzites are probably the oldest rocks of the field. These are traversed by dykes of granitic origin, and these in turn appear to be of great age, as they have shared in the whole of the regional metamorphism of the district. It is probable that the older fine-grained masses of granite lying in the Four-mile Creek, and in its neighbourhood, either sent out the older dykes that pierce the sedimentary rocks, or were at any rate contemporaneous with the older dyke-forming epoch.

To the south a coarser and greenish granite has been intruded into the slates. In places it is a felspar-porphyry. It is in the shape of a huge bar running east and west, and cut off, both to the east and west, by the coarser granite of the field.

Subsequent to this intrusion a large mass of biotite granite, or granitite, penetrated the older masses, and cut across the slates and other sedimentary rocks from east to west.

The bluff of rocks, west and north-west of the Baker's Creek Company's workings, represents the material forced into the slates by the latest granitic intrusion. It differs from the other plutonic masses in not being of coarse texture, but showing to the unaided eye simply a very fine crystalline appearance.

After a long period of quiescence, during which the great granitic bosses were first exposed, then eroded nearly to their present level, Tertiary basalts made their appearance, diverting the rivers into new channels.

(*a*) Sedimentary Rocks.

Possibly the oldest rocks on the field are the altered slates, schists, and quartzites. These in the Hillgrove area itself are confined to a sub-rectangular shaped mass, two miles in length and some three-quarters of a mile in breadth. A narrow strip of altered slate is continued on from the main mass in a westerly direction, and contains the Sunlight lodes in its course. This small belt averages but a few hundreds of yards in width. A great bar of granite has cut across the direction of the slate outcrop, some 1,000 yards below Baker's Creek Mine workings, and from that point the slate continues for miles down the creek, but with a slightly varying strike. On the gold-field itself, the sedimentary rocks consist of slates, knotted schists, mica schists, quartzites, siliceous schists, and siliceous slates, much contorted in places, but generally preserving a strike N. 20° W. Between Murgatroyd's tunnels and the Garibaldi dam the strike passes gradually from N. 8° E. to N. 23° W., and the dip changes from a slight easterly direction to an almost insensible westerly one. In one place, between the tunnel and the dam, the dip is vertical. At Whittaker's Spur and the Swamp Creek, local disturbances have bent the slate sharply. Two readings taken in the Swamp Creek were respectively 35° and 70° towards the west.

In rare instances both dip and cleavage show beautifully, and the slates are black and blue-black in colour, with white intercalated bands coinciding with the strike of the beds.

Mr. W. S. Dun, Palæontologist to the Geological Survey, has examined several of these rocks in thin sections under the microscope, for the presence

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of radiolaria. One of these had the appearance of a radiolarian rock, but was too much altered for the satisfactory preservation of these organisms. Others exhibit no traces of radiolaria.

Again the slates often pass insensibly into a knotted or spotted schist. Near the centre of the area occupied by the derivative rocks, a curious rock mass occurs, which on superficial examination shows a striking resemblance to a fine-grained igneous rock. It is, however, of sedimentary origin. Interbedded with this rock are thin beds of spotted or knotted schists. By determining the direction of the schist and "highly altered" rock-junction, the strike of the latter was arrived at; it was N. 10° W.

Towards the Four-mile Creek, quartzites, siliceous schists, and mica schists occur, but the rocks are too altered to show signs of dip and strike at the surface. For a similar reason there appears to be no trace of former organisms that may be contained in the strata. A soft, black, cleaved slate, occurring several miles down the creek was searched for fossils, with no success however, although everything seems favourable in the slate for the preservation of organisms.

Several prominent jointings occur in the slates. Of these two are very marked, one occurring at an angle of 15° to 20° to the strike of the beds, and dipping at a high angle. The other is of lower angle, rarely exceeding 20° or 30°. Another subordinate system of jointing is also common. Plate III illustrates well the most pronounced of these jointings.

(*b*) The Eruptive Rocks.

The First Granitic Intrusion.—The remains of an old granite rock are found in various parts of the field, particularly in the bed and eastern slope of the Four-mile Creek, near its head. In places it has the appearance of a fine-grained white sandstone, in others of a fine-grained but much altered granite. In the Four-mile Creek it appears to be broken into by the main granite mass of the field. In the bed of the same creek, a mass of angular fragments of a fine-grained rock are cemented together by larger and smaller veins of a younger and coarser intrusive rock, which has broken up the finer-grained mass. These fragments may belong to an older granite mass. Professor David has informed me of the frequency with which, in New England, a coarse granite has broken and intruded into an older finer-grained rock. In walking from Bolivia to Deepwater, along the railway line, one sees splendid illustrations of this intrusion of coarse granite into fine, exposed in the cuttings. It is possible that the oldest dykes of the field which show so much evidence of metamorphism, represent one phase of this older granitic intrusion. These dykes are green in colour, and weather out into a yellowish or brownish earth showing much decomposed micaceous material.

Second Granitic Intrusion.—There is another granitic mass on the field which appears to be older than the wide-spread coarse granite. It runs as a belt east and west across the southern part of the field, and is exposed only in the Baker's Creek gorge, where the coarser granite has truncated it at both extremities. In a small creek on the Long Point Spur, a whole mass of sub-circular fine-grained fragments have been caught up by the coarser granite rock. The phenomenon occurs near the granite and schist junction.

The rock is generally compact, fine in grain, and green in colour owing to its wealth of decomposed ferromagnesian minerals. The red soil resulting from its decomposition, its green colour and its weight are suggestive of a more basic origin than granite. Its innumerable segregations are notable, both in forms of veins and irregularly shaped masses, as much as ten yards in

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diameter. The edges of these latter shade off insensibly into the enclosing magma. The minerals enclosed are quartz and felspars. The coarse segregations have the appearance of gabbros or diorite from the colour, the occurrence of the ferromagnesian constituents, and the great quantity of striated felspar. Near the junction of this rock with the slate, a mass of broken fragments occurs similar in appearance to kindred displays mentioned in previous paragraphs. This broken mass is not confined to a mere selvage in width, but persists for a distance of some two or three hundred yards, measured at right-angles to the strike of the slate and granite junction. Both at the Long Point Creek spur, and in the bed of the Four-mile Creek, this brecciated appearance occurs near the sedimentary rocks.

Huge dykes have been sent by this mass into the surrounding slates. They are highly altered ; they show large white felspars and at times elongated blue quartzes ; they have generally been thought to be diorites.

The Third Granitic Intrusion.—This, the main acid intrusion on the field, is important as regards its mass, its action on the sedimentary rocks, and the part played by it in the formation of the lodes.

In appearance this coarse granite is black on fresh fractures, by reason of the abundance of dark mica, and it also contains much plagioclase. Large idiomorphs of felspar, with corroded contours lie scattered plentifully throughout the mass. It is markedly gneissoid, crushed or otherwise altered in places.

Most of the gold and antimony lodes are connected with this boss, besides which the scheelite veins, almost without exception, are contained in it.

The Latest Granitic Intrusion.—The last granite outburst connected with this field occurs as a bold escarpment, 400 yards wide, 1,500 feet in height, and in position exactly opposite the Baker's Creek Mine tramway. It is exceedingly fine in texture, very tough, and has a glistening appearance on fracture. Most of the miners of the field are so deceived as to its true structural affinities as to designate it a baked or hardened slate. Plutonic rocks consolidate as fairly coarse crystalline mineral aggregates—to wit, the other granites of the field—and are supposed to have cooled at great depths below the surface, but cooling appears to have acted rapidly in this granitic mass, as though it had consolidated nearer the surface.

The tailings in the creek near the Sunlight, Baker's Creek, and Proprietary Mines, obscure a history that would otherwise be easily read concerning the relative ages of three of the granitic masses of the field. Enough is exposed, however, to show that a long tongue of felspar porphyry, sent out from the green granite to the south, passed through Murgatroyd's and Trimm's tunnels, and was cut through by this latest eruptive rock. Beyond the fine granite, traces of the felspar porphyry tongue exist as dykes near Baker's Creek workings. This fine rock has also sent narrow felsite dykes into the slate. In one place near the Sunlight bridges, the hard black slate is pierced by narrow ribbons of felsite, more or less parallel to each other. Many of them are of the character of small sills, and, generally speaking, they supply clear evidence of the intrusive nature of the granite. The habit of this intrusive rock is more that of a dyke than a boss. Measurements taken near the Sunlight Reef indicate a vertical slope for the granite at that particular spot. Two or three long lines of dykes passing through the coarse granite were traced to within a couple of hundred yards of the granite under consideration. In appearance they were similar to undoubted dykes sent out from the fine-grained rock.

Dykes.—A reference to the map will serve to show how many occur in the restricted area of the mines. The beds of Baker's and Swamp Creeks are full

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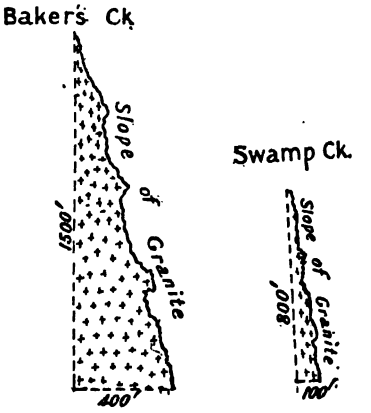
of them. Several accompany lines of reef—*e.g.*, the Eleanora. Others break across reefs. Some appear to have partaken in all the general metamorphism of the area—*e.g.*, the Eleanora and Freehold dykes. Another felsite dyke, four feet wide, running like a wall up a vertical bluff of slate two hundred feet high, outcrops near the Garibaldi dam. This rock contains numerous crystals of hornblende and epidote. The Little Reef in its northern end, the Creek near the Sunlight battery, the Upper and Lower Cooney tunnels, are all intersected by these granitic intrusions, while great felspar porphyry dykes, ten feet wide, cross the line of the Little Reef, Portion 176, Murgatroyd's tunnel, and Baker's Creek; these proceed from the green granitic mass to the south.

The Slopes of Granite Bosses.—Observations in Baker's Creek, Swamp Creek, and Four-mile Creek, give much steeper angles of slope for the granitic bosses than might be expected. The junction of slate and granite on the eastern and western lips of the falls was obtained in these creeks, and the position of the junction between these two rock types was also fixed in the creek bed. Then, by drawing a line at right-angles from the junction in the creek to a line joining the two fixed points on the edges of the falls, an approximate idea of the original granite slope was obtained. In Baker's Creek the granite had advanced 400 feet in a vertical height of 1,500 feet—*i.e.*, less than 1 in 3. In Swamp Creek the advance was 100 feet for a vertical drop of 800 feet. In the Four-mile Creek the slope was almost nil, and in the Sunlight lode, also, the slope approximated to the vertical. The slope of the Sunlight granite was observed per medium of the tunnels.

Sketches showing the slopes of the Granite Bosses in Baker's and Swamp Creeks.



(*c*) Metamorphism.

The metamorphism of the slate has been alluded to before. In places the rock has been altered almost beyond recognition, soft black slate being changed to hard siliceous varieties; rocks belonging to the nodular and spotted schists, and one resembling a fine-grained variety of eruptive rock. In both slates and older granites numerous lodes occur, and cross-courses of two pronounced types, both of which have altered the country, causing heaves from an inch to twenty feet.

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In one place in Baker's Creek a peculiar phase of metamorphism is found in the so-called explosive slate. Along the Little Reef, on the lower levels, particularly Nos. 10 and 11, and in the upper levels of the Sunlight Reef, a variety of slate is worked that tends to explode or "kick" spontaneously. On striking, or on boring with a drill, this treacherous ground will fly out in all directions with great violence. On one occasion a couple of miners were drilling a hole in No. 11 level, when a "kick" occurred. A lump of stone, about 50 lbs. weight, was hurled out of the wall, and after passing through a 3 in. x 2 in. scantling, cut a man's body in two. Another driller lost an eye, another his nose and scalp, while many have been buried in the débris attendant on one of these outbursts, but these have escaped with bruising. Stulls placed normally to the walls are frequently smashed, or the ground about the foot of a stull is driven out, leaving it on a small shoe of slate remaining on the foot wall. For days before a "kick" occurs along a bad level the slate "spits," and fragments are given off at intervals. All that is then needed is a sharp hammering or a drill hole to be put in for an outburst to take place. Along No. 11 level this slate occurs in slabs, polished on the outside, while inside it differs in no respect, macroscopically, from an ordinary hard black slate. The best examples of the "kicking" rock have the marked jointing of the field, but break with conchoidal fracture, and are curiously curly in structure.

It seems to be merely a result of great pressure, derived probably from the compressing forces exerted by the various local granitic intrusions. In driving levels this "kicking" is rarely observed. It is only when the pressure is still more relieved, as for example, by stoping, that the slate bursts out with the force of a dynamite shot. Some observers imagine the slate has been subjected to fusion, and they find an analogous case in that of the Prince Rupert drops, which are pieces of molten glass, suddenly cooled by causing them to drop into liquid while in a molten state. A thin crust of cooled glass forms immediately, but the whole central portion is held in a state of such strain that on allowing one of the "drops" to fall, the thin outer ring of rapidly cooled glass cracks, the pressure is relieved, and a violent explosion occurs. The two cases are not identical. In the first place the "drops" are of fused material, while the palæozoic slate has suffered nothing like fusion. Even had the slates been fused, at the great depths they occur they could not have cooled quickly, so as to have a pent-up central portion inside a rapidly-cooled shell. Another group of inquirers has referred the origin of the explosions to pent-up gases in the slate, but this is as untenable an hypothesis as that of fusion.

If an elastic body could be pressed down by some Herculean force so as to occupy a smaller space than it would under normal conditions, and then secured in this position by strong steel clamps, so fixed as to form an immensely thick "strong box," encasing the imprisoned body, we can form some idea as to the behaviour of the slate. The removal of one or two clamps would make no perceptible difference in the state of the imprisoned body. As, however, the releasing process was continued, there would come a time when perfect equilibrium would exist between the forces of expansion and compression. Then the least further release would result in an explosion. This seems to be the condition of things on the Little Reef levels. Several series of granitic intrusions have occurred in the vicinity, causing, especially during the last intrusion, great compression of the slates. The driving of a level along this tightly packed area results in "spitting" and minor "kicks" only, as the side thrusts of the walls and other forces would keep the solid rock fairly intact. As, however, stoping went on, thus relieving pressure in more than one

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direction, the expansive and compressive forces would approach the state of equilibrium. This would be heralded by the "spitting" of the slate. When the state of equilibrium was reached, the least tap with a hammer would result in a disastrous explosion. Frequently this stage is reached by firing a shot; tapping, after this, is attended with "kicking."

Another feature is the metamorphism of the older granites of the field, where crushing has taken place. In some of the coarser granites, notably the green basic variety, south of the gold area, a structure has been induced by dynamic metamorphism that resembles the bedding of stratified material. In others the quartzes are elongated into sub-elliptical forms, and in places appear to be of secondary origin. Frequently whole areas of rock are polished, and coated with green material, wrongly called serpentine by some mining men. Plumbago is present in some quantity in portions of the older green granite, and flucan derived from the crushing of this rock is at times quite black and tough.

(*d*) The Lodes.

The largest and most important of these have a north-westerly and south-easterly course, and underlie to the east at a steep angle, varying from 0° to 25° from the vertical. In the case of the Eleanora and Freehold Reefs, large dykes follow their strike closely. The Big and Little Reefs, the Middle Reef, and Hill's Reef, are crossed by dykes. When dykes follow the reefs they are older than the lode material. Thus the Eleanora and Freehold Reefs appear to have opened along the line of the dykes, and to have been charged with minerals subsequently. The continuation of some of the large reefs into the main granitic mass, the general parallelism of the strike and dip of all the main reefs, the ore characteristics of the same, and the general north and south tendency of the principal cross-courses, all tend to prove a common age and origin for the lodes, and that origin to be traced to the main granitic upheaval. It is very probable that the main lodes were determined by the upheaval of the granite and the cross-courses by its settling down; the lodes dip to the north-east, and occur on the eastern side of the main granitic axis of the district. The Sunlight lode has opened again since that time, possibly as a result of the latest granitic intrusion. The Middle and Little Reefs intersect, but do not throw each other. According to Mr. Barnet, formerly underground manager in the Baker's Creek property, the Middle Reef was strong at the intersection, while the Little Reef was reduced to a few irregularly-distributed quartz threads.

A predominating system of cross-courses runs north and south, and underlies to the east, and gives rise, generally, to "right-hand" heaves of the lodes. Their underlie varies from 0° to 20° from the vertical. Gold frequently occurs in their neighbourhood. Another set of cross-courses have a more east and west direction, and these also have thrown the reefs. In isolated cases reefs have been thrown as much as 12 feet out of their course. In the case of the Eleanora Reef, the lode occurs on both sides of the dyke. Where the dyke has made a slight roll horizontally, the reef appears to "sit" on the bulge so caused. When the reef opened alongside the dyke, and the hanging wall slipped on the foot wall, a massive slate breccia was formed, which was cemented by quartz and sulphide of antimony, deposited from ascending thermal waters.

The reefs consist principally of quartz alternating with stretches of barren crushed slate and quartz, or hard slate. Polished surfaces are frequent, as also flucan bands. In the granite lodes a green selvage of crushed ferro-magnesian rock is visible.

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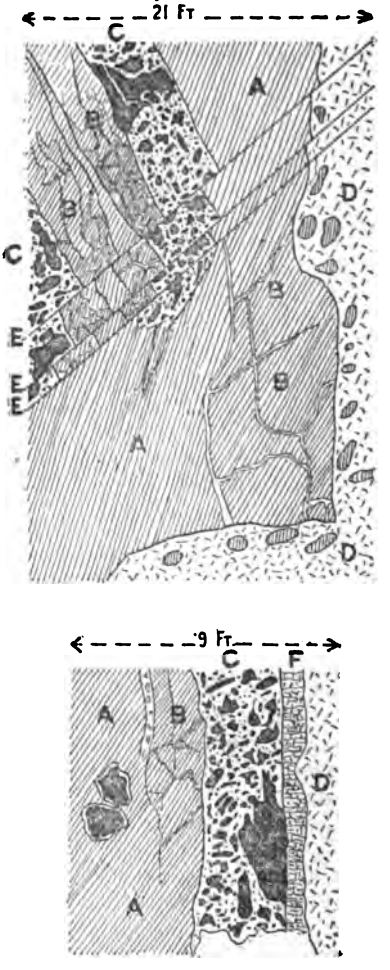
The scheelite lodes pinch in and widen out with astonishing rapidity. They are mostly small deposits, and antimonite is associated with the scheelite. In the Hopetoun, gold is said to pinch out when the scheelite makes, and *vice versa*.

The principal matrix of the gold is quartz, but stibnite also is present in great quantity, sometimes as magnificent crystal specimens filling vughs, at other times in hair-like masses, and at others amorphous. Some specimens look much like Jamesonite.

The quartz is translucent to white and opaque. The breccias of the Eleanora and Sunlight Reefs are distinctive, both as to the general shape of the slate fragments and the quartz cementing.

Roof of Drive in North End of No. 6 Level, Eleanora Mine.



Reference.—A Jointed slate. B Slate traversed by net-work of quartz veins. C Slate breccia cemented with transparent and white quartz. D Felsite dyke filled with nodules. E E E Faults. F Antimony.

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In the unoxidised ore the metallic minerals, besides gold, are sulphide of antimony, arsenical pyrites (white mundic), and a little bournonite (?).

In some of the reefs good gold is visible; especially is this the case in the Little Reef, where specimens occasionally turn up quite thick with coarse gold. The gold is often quite red, having the appearance of copper.

The steepness of the gorge slopes seems to prevent the accumulation of thick oxidised ore masses, as the heavy and frequent rains would sweep this softer material into the gully.

The reefs are often 12 to 18 inches thick. The Big Reef outcropped strongly on the surface, showing 4 feet width of stone. The Little Reef, however, is but a filament of quartz over long distances.

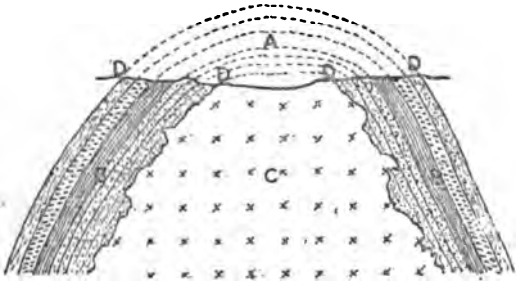
Besides gold, which ranks first in value among the mineral products of the field, antimony has been and is still, in a less degree, a source of profit. Of late the discovery of bodies of scheelite has opened up quite a field for the smaller miners and fossickers, as the coarse granite appears to contain innumerable small lodes of this mineral.

(*e*) Geological History subsequent to the Formation of the Lodes.

This is recorded principally in the wondrous amount of degradation that the rocks, once superior in position to the granite, have been subjected to. This area is a fine example of "earth sculpture" by epigene agents on disturbed slate and disturbing granite. The plain of accumulation, caused by carboniferous or older sediments, which had been laid down by the sea, was intruded and forced into folds by the great carboniferous (?) granite massif now forming the axis of the New England plateau. The exact amount of sediment eroded since this distant period is not known; but it must be enormous, since the Carboniferous or earlier formed strata, the highly inclined relics of which are greatly in evidence around the gold-field, are some thousands of feet in thickness.* A reference to the diagrams will illustrate this:—

Carboniferous (?) Slates, &c., horizontally bedded before Granitic Intrusion.

Carboniferous (?) slates, &c., folded by Granitic Intrusions.



A Original anticline removed by denudation. B Sedimentary rocks—Carboniferous (?) slates, &c., after granitic intrusion. C Granite massif. DDDD Present surface

* For particulars of this, see Professor T. W. E. David's description of New England in Gympie (?) times, in his Presidential Address to the Royal Society of New South Wales, 1894.

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The right-hand side of this section, D′ D′, gives some idea of the appearance seen to-day in the district,† which is the eastern aspect of the great anticline. Clearly the portion represented by the dotted lines must have been carried away by epigene agents. And this has been done so effectually that the flowing contours of the present hills show to the untrained eye, no trace of degradation from a mountain system to a low plateau or plain. The river system of the ancient granite plateau was a fairly mature one, as the forces of erosion had reached that stage when the soft contours which mark the "death of the mountain" had succeeded to the peaks of circumdenudation, with the usual accompaniments of buttress and precipice that had resulted from the forces of erosion acting in the earlier stages on the Palæozoic slates.

Later in geological time, a great Tertiary basalt outburst flooded the Hillgrove and Metz area, filling the water-courses, and forming flats here and there. Previous to this event Baker's Creek and Gara River were united, and flowed where the town of Metz now stands. The basalt outflow diverted these streams into different channels. The waters now forming Baker's Creek attacked the highly inclined slate, and hollowed it out along the line of outcrop, thus carving out for themselves approximately meridional channels. The slates were rapidly eaten back, particularly in spots where, as at Swamp Creek, there was any resemblance to anticlinal structure, until the great east and west line of granite and slate junction was reached. The cuboidal jointing of the granite soon led to its degradation in turn, but not along the rapid lines that the slate had been attacked. This explains the appearance of the creeks to-day, with their deep gorges in the slate country, and precipitous and narrow ravines in the granite. The whole of the Baker's Creek ravine, as also that of Swamp Creek and Four-mile Creek has been eroded since Tertiary times—possibly Pliocene. (Plate IV, also plan.)

(*f*) Petrological Notes on some Hillgrove Rocks.

Both in macroscopic and microscopic examination the rocks of the Hillgrove area exhibit the influences of metamorphism. The ferromagnesian elements may be observed to pass into large masses of brownish or green material. They are rarely seen in a clear state, but are often replaced by viridite. The felspars are faulted in a remarkable manner, and are frequently kaolinised or replaced by epidote, secondary quartz, and secondary felspar. Much of the felspar being plagioclase, it alters in conjunction with the biotite to saussurite. The prevailing types of rock at Hillgrove belong to the granitites, although a red rock at Gara shows affinities with true granites. These granitites in places are of very basic variety. One or two types would, by some observers, be referred to the intermediate rocks. Mr. J. A. Watt, M.A., B.Sc* classes the eruptive rock containing the gold lodes at Wyalong as a very basic granite, showing great affinities with the quartz-mica diorites of some petrologists.

The holocrystalline rocks of acid composition in New South Wales will be found very frequently to belong to the granitites rather than to the true granites.

Slide 1,669.—Biotite granitite from main granitic mass, near Township.

Macroscopic Characters.—A dark holocrystalline rock, porphyritic, with large felspars, rectangular to sub-elliptical in outline. Decidedly gneissic in appearance.

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* Mineral Resources, No. 5, page 15.

† In reality, the strata were thrown into a series of folds, and were faulted in many places.

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To face page 22.

BAKER'S CREEK GORGE, LOOKING SOUTH FROM CAMPBELL'S SPUR.

Plate IV.

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Microscopic Characters.—This rock is full of plagioclase, orthoclase being poorly represented. There are two crops of felspar. The first crop consists of phenocrysts, as much as two inches in length, representing the intratelluric phase of crystallisation. Many of these crystals have edges so corroded as to have lost their original rectilinear outlines and to possess sub-elliptical contours. Some of the triclinic felspars belong to the potash variety known as microcline, having an appearance of plaited basket-work under crossed nicols. Albite and carlsbad types of twinning are observable at times in the same crystal. Schillerization occurs in certain crystals. The second crop of felspar consists mostly of small plagioclase crystals of glassy habit, twinned on the albite plan. Interpenetration twins and compound multiple-twinning not uncommon. Biotite and muscovite are both present. Some of the less decomposed of these polarise in high colours; the edges are frayed, and the crystals are often drawn out into long curvilinear lines. Decomposition products are present as viridite and saussurite. Quartz is present in fair quantity, also in secondary form; sometimes observable in the centre of plagioclase crystals. Scattered grains of a mineral possessing fairly high refractive index occur throughout the slide. Under crossed nicols the colours are dark blue to black. Apatite is present in quantity as rods and stout crystals. Magnetite also occurs. Lustre-mottling is also observable in this slide.

Slices from Rock Specimens 3,908, 3,913, 3,665.—Locality, Baker's Creek, near junction with Four-mile Creek. These rocks represent phases in the cooling of a very basic granite. They are much altered, and flow structure is not uncommon.

Macroscopic Characters.—Dark holocrystalline rock showing bronze-coloured micas, decomposed hornblendes and biotites.

Microscopic Examination.—The felspar is represented principally by plagioclase. Much of this is kaolinised, while a later crop of the same mineral is of lathlike and glassy habit. Beautiful examples of faulting occur in the felspars (Plate X), and in other crystals under crossed nicols, the alternate light and dark bands, due to multiple-twinning, are in curved lines as a result of crushing. The plagioclase in places is altered to epidote, as grains and irregular patches. Several crystals possess a thin outer-ring only of felspar, the centre being occupied by epidote. Individual crystals show twinning on both carlsbad and albite plans. Ferromagnesian minerals, as biotite and hornblende, are present in great quantity. Both are generally highly altered and the slides are full of viridite and a fair proportion of saussurite. Muscovite is also present. Primary quartz is a minor constituent. Secondary quartz is present. Apatite and magnetite are well represented.

This rock has a high specific gravity, and by some petrographers would be referred to the acid end of the diorite group.

Rock Specimen 3,911.—Granite from Gara River, five miles west of Hillgrove township.

In hand specimens this appears as a beautiful pink holocrystalline rock of medium coarseness. Strings of epidote occur throughout the rock.

Under the microscope the felspar is seen to consist of both triclinic and orthoclase varieties. Orthoclase is present in abundance, the crystals being quite cloudy through kaolinisation. Sections of plagioclase occur showing interpenetration twins. Both orthoclase and plagioclase are crossed by strings of epidote.

Much decomposed biotite is present. Quartz is greatly in evidence, the crystals being quite speckled by reason of numerous liquid and gaseous inclusions.

Apatite occurs in stout prisms and long needle-like forms. Iron pyrites is present in abundance.

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Rock Specimen 3,999.—Fine-grained granite from Four-mile. Extremely altered, having appearance of fine-grained white sandstone in places. Biotite is present, but much altered, sheared and drawn out in threads by dynamic metamorphism. Felspar occurs as plagioclase and orthoclase, much kaolinised. There is a great development of secondary quartz. This rock belongs to the oldest granite of the field, and shows relationship with the granitic inclusions in the main mass.

Rock Specimen, 3,966, *Slide* 3,966.—Quartz-felspar porphyry from No. 3 level of the "Little Reef," Baker's Creek Mine. This appears in hand specimens as a fine-grained dark rock, porphyritic with white felspar crystals.

The microscopic examination of this rock reveals the influence of long continued metamorphism. The base is microcrystalline to cryptocrystalline, and exhibits "flow structure" in the vicinity of the porphyritic constituents. These latter consist of idiomorphs of plagioclase, representing the intratelluric stage of crystallisation. Interpenetration twins and cross-twinning are common. Zonal structure is noticeable in the plagioclase. The second crop of felspars is composed of stout squarish triclinic and orthoclase crystals.

The biotite is much altered in places to non-pleochroic brown and green products, and appears drawn out into wavy lines. Apatite and iron oxide are present.

Rock Specimen 3,967.—Felsite from dyke near Garibaldi Dam.

Cyptocrystalline base, with numerous small hexagonal and lozenge-shaped sections of transparent greenish-brown amphibole.* These crystals are of rod-like habit, and exhibit twinning. The mineral is pleochroic. Sections cut parallel to the plane of symmetry yield more brilliant colours under crossed nicols than those cut in the orthodiagonal zone.

Epidote, apatite, and magnetite present.

Rock Specimen 3,970.—Dyke in Swamp Creek. This rock is a felsite of much fresher appearance than the ordinary types of Hillgrove eruptive rocks. Micas are very plentiful, with well preserved edges and exhibiting brilliant polarisation colours.

Rock Specimen 3,971.—"Kicking" slate from No. 11 level, "Little Reef."

This rock possesses a remarkable curly structure, and contains veins of secondary quartz. Alteration products are present.

Notes on the so-called "Pebbles" of the Eleanora Dyke.

The dyke-rock belongs to the basic granitic type, and is much decomposed, the biotite being changed to viridite, and the plagioclase to saussurite.

Throughout the dyke, numerous pieces of a much decomposed and very basic rock occur, having the rounded contours characteristic of pebbles. In places where the dyke has bent slightly from a straight course, the included portions occur in such abundance as to resemble a conglomerate. These fragments fit into distinct sockets, and may be released, when they impress the uninitiated with their pebble-like habit.

They consist of ultrabasic material, much decomposed. Their specific gravity is 3, and the abundance of viridite present causes them to possess a greenish colour.

Very few similar occurrences have been notified in New South Wales.

Mr. J. E. Carne, F.G.S., Geological Surveyor, has described† a nodular felsite from Pambula. In this case, however, the nodules appear to be simply segregations of the felsite magma itself.

* Both Mr. G. W. Card, A.R.S.M., and Mr. W. S. Woolnough, B.Sc., agree in referring this mineral to the amphiboles.

† Annual Report of the Department of Mines and Agriculture for 1896, page 111.

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The Pennant Hills basalt quarry contains numerous rounded pieces of an ultrabasic rock, containing chromite or picotite, olivine and magnetite, and representing probably a variety of dunite. Professor T. W. E. David, of Sydney University, suggests that the basic magma in its upward progress caught up fragments of an ultrabasic rock, and subsequently corroded the fragments so caught up, till they presented the appearance of sub-ellipsoidal masses.

A similar origin may probably be assigned to the Eleanora "pebbles," but whereas in the Pennant Hills pipe the magma is basic (olivine-basalt), in the Hillgrove case the magma is an acid rock, or one belonging to the upper or acid end of the intermediate group. Mr. W. S. Woolnough, B.Sc., of Sydney University, suggests that, owing to the acid nature of the magma, there should exist a zone of intermediate composition between the nodules and the dyke matter proper.

Mr. E. F. Pittman, Government Geologist, mentions the occurrence at Lucknow of rounded masses of augite andesite at or near the junction of huge masses of andesite and serpentine. The augite andesite blocks are completely enveloped by the serpentine.

6. LIFE OF THE REEFS AT THE LOWER LEVELS.

(1.) Granite generally occurs as bosses, *i.e.*, more or less dome-shaped masses, with the broader portions as bases.

(2.) The granite bosses of Hillgrove have a very slight inclination from the vertical, as shown in diagrams elsewhere.

(3.) The fine-grained intrusive granite near the Sunlight Reef and the Baker's Creek properties appears to be almost vertical in slope.

(4.) The slate belt is excessively narrow where the gold occurs.

(5.) The granite almost abuts on some of the reef lines.

(6.) The *main* granitic mass of the field does not appear to cut off the lodes, and actually carries some, *e.g.*, the Eleanora and Freehold Reefs, continued into the granite. The Hopetoun, Starlight, Centennial, Carrington, and Cosmopolitan lodes are contained wholly in the granite.

(7.) The last and finest granite of the field appears only as a destroyer, and not a maker, of gold reefs, and cuts across the strike of the Little, Big, and Baalgammon lines of reef at a short distance from the creek.

It therefore seems useless to spend time and money in the exploitation of the country to the north-west of the Baker's Creek property. As to the Baker's Creek property lines of reef, dipping away as they do from the fine-grained granite, and towards the reef-forming granite mass to the north, it seems unnecessary to make any comment. A reference to the general section will illustrate their position with respect to the fine-grained granite mass.

The Sunlight varies in distance from 60 to 200 yards from the fine-grained granite, and dips towards it. A reference to the plan of the field will show its approximate parallelism of strike to that of the granite and slate junction close by. The granite, however, as observed in No. 5 tunnel, and at the surface, has very little inclination towards the reef, and therefore may not affect it for a great depth, except as a little crushing and by faulting, and this only at its eastern end.

The Eleanora appears to be derived from the main granitic mass close by, and no other igneous rock, except the dyke, is close at hand. It may also be noticed that only in the vicinity of the main granitic mass are the reefs

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payable, none of the reefs being traced into or to the neighbourhood of the greenish granite to the south. It must be remembered that much of the granite to the south of the Sunlight is of the same character as that of the main mass, its exact line of junction with the greener rock not being ascertained.

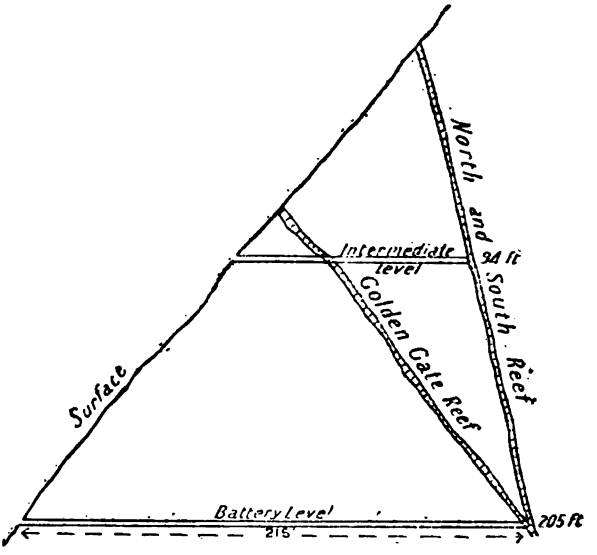
7. DESCRIPTIONS OF MINING PROPERTIES.

The order selected in this description of reefs and properties is not intended to be at all indicative of the proportionate value of the properties enumerated, *e.g.*, the most valuable block on the ground is that of Baker's Creek Company, which is described in the closing pages.

(*a*) The Golden Gate Reefs.

These reefs were worked first for antimony (?). Up till seven years since they were held by different parties, and eventually fell into W. Miller's hands. Thomas Snow, of Hillgrove, took them then on tribute from Miller, who resided at Armidale. It afterwards passed into the hands of the Australasian United Exploration Co. This was in February, 1897. At that date it was by them amalgamated into the Hillgrove Proprietary Mining Property, Ltd. In April, 1898, the Cooney Proprietary Co. amalgamated with the latter, and as such it remains. For this information I am indebted to Mr. H. M. Porter, Manager for the Cooney Proprietary Co.

Sketch illustrating method of working the "Golden Gate" and "North and South" Reefs.



Two reefs run through this property, viz., the Golden Gate Reef and the North and South Reef. The ore has been won from these by tunnels driven into them from the hill side. The strike is approximately N.-W., but it varies very much owing to numerous faultings and crushings. It underlays steeply to the east. The Golden Gate Reef itself underlays 35 feet in 100 feet vertical descent; in 205 feet it underlays 94 feet.

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The Golden Gate and North and South Reefs intersect at a distance of 215 feet from the mouth of the tunnel, and 205 feet below the open cut of the North and South Reef. According to Mr. Thomas Snow, this carried 2 ounces of gold to the ton. Underhand stoping has been carried on for 40 feet below this level.

The new company did a little work here in September, 1897. A winze was sunk 197 feet 6 inches from the tunnel on the top into the North and South Reef to the bottom level of the Golden Gate.

At the intermediate level the cross course was driven on, and the south wall was stripped for a distance of 66 feet, but no reef was exposed. The Golden Gate Reef was lost for a time owing to the intersection of three or four cross courses.

Through the courtesy of Mr. Thomas Snow, formerly manager of this property, the following returns are published here. The crushings were performed on the spot with a 10-head battery.

From the east reef, known as the Golden Gate Reef, the top level yielded 1,000 oz. of gold for 1,500 tons of ore crushed.

From the lower level 600 tons were crushed for a yield of 900 oz. gold, and from the North and South Reef, 1,000 tons were crushed for 200 oz. of gold.

Total, 2,200 tons for 2,100 oz. of gold.

(*b*) The Proprietary's Claims.

These consist of various properties, viz., the lower and upper Cooney tunnels, the rise into Baker's Creek No. 3 level, and extension also of the same. (*Vide* diagram.)

The workings performed by the old Baker's Creek Co. are all connected by means of the main Cooney tunnel.

This fine tunnel starts from the northern boundary of M.T. 11, about 2 chains from Baker's Creek. Its course is straight and is N. 23° 18′ E. Up till 1st April it had been driven into the hill 2,054 feet. It is about 8 feet high and 8 feet wide. This was a portion of the property held by the late Baker's Creek South, which company abandoned the ground some years ago after driving some 300 feet into the hill. It then lay idle until a local syndicate, known as Baker's Creek No. 1 Extended, applied for a tunnel site to enable them to prospect the blocks lying to the south of the Baker's Creek Mine. This syndicate cut the tunnel down, making it wider, and extending it for a further distance of 100 feet. The total distance driven till then was 405 feet. Then the United Australian Exploration Co. purchased the ground held by the syndicate, and since that time the company have continuously extended the tunnel. It was proposed to drive the tunnel a distance of 2,000 feet into the hill and then pick up the Golden Gate Reefs.

In driving the tunnel a number of veins had been cut, as many as seventeen different ones being struck between the 992 and 1,671 ft. marks. A shaft is being sunk on the first one met with, supposed to be the "Little" Reef. As five others have been cut close to it, it is doubtful which will be the prize—to wit, the "Little" Reef. This is at a distance of 992 feet from the mouth of the tunnel, where a chamber has been cut out to allow of hauling gear to be set up. The shaft is a main underlay one, and is being carried down at a uniform angle of 72° 30′. The system of timbering adopted is that known as the "Colorado"—usually employed in America. It consists of heavy timbers or main sets following the underlay, and all cross-pieces are set normally to the underlay also, so as to overcome side thrusts from the walls

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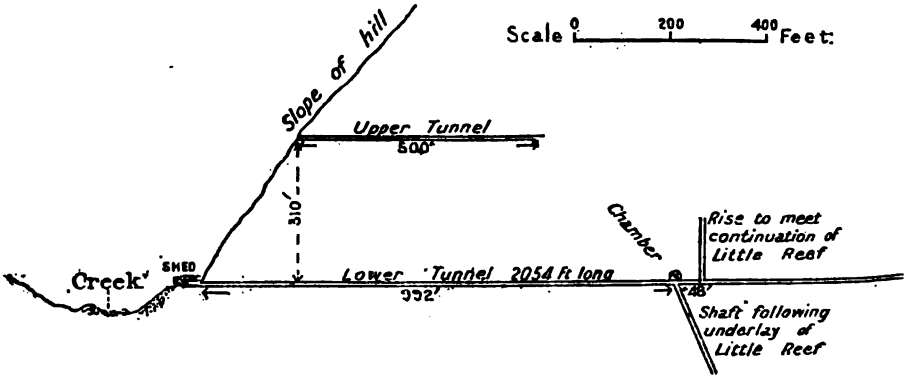
The platforms in the ladder-way are also normal to the shaft walls, and ladders are attached to the footwall. This is also known as the "square-set" system.

At 1,040 feet from the entrance, a rise was put up 138 feet, and connected with the extension of No. 3 level of Baker's Creek workings along the "Little" Reef. This extension of No. 3 level consists of a zigzag system of crosscuts to pick up the southern continuation of the reef. It is very possible that the reef was lost all this time. (*Vide* diagram.)

The upper Cooney tunnel is in portion 182. It was driven 500 feet in a direction N. 44° E., and it lies 310 feet above the lower tunnel. It was driven by the Baker's Creek South Co. The present proprietors have driven 162 feet on a vein at a distance of 400 feet from the entrance. The diagram explains the relative positions of the workings.

Section across Proprietary tunnels. Both tunnels are projected into one plane. The direction of the Lower Tunnel is approximately at right angles to the strike of the "Little" Reef.



The Proprietary Company, being possessed of an enormous capital, are determined to save no expense in establishing a proper mining plant on the field. An air compressor is in use which, by compressing air to the extent of 80 lb. to the square inch, and working at 80 lb. pressure, can keep six to eight rock drills at work. The air is conveyed down the gorge by a straight cast-iron pipe, 5 inches in diameter, 2,308 feet in length to the mouth of the tunnel, and 2,000 feet along the tunnel itself. The difference of altitude between the engine and tunnel is 1,500 feet. The piping on the hillside (2,308 feet long) is provided with eight expansion pieces, each of which working on a sleeve is allowed a slide of 17 inches. The gorge is subject to extreme variations in temperature. An extreme movement of 7 inches has been noted on one sleeve. Six rock drills are used by the Company; three "Nationals," two "Ingersolls," and one "Little Giant." With a "National," one hole 5 inches deep was bored in twenty-two minutes in the slate. It may be noted in passing that certain bands in the slate of this field are extremely difficult to pierce. A banded, dark black, or a curly grey slate gives the most trouble. According to Mr. H. M. Porter, some of it nearly approaches the topaz rock of the Emmaville emerald mines in hardness. Of the machine drills, the National is probably the most serviceable on the field. The Ingersoll appears to work a little more speedily, but the

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chuck attachment for holding the drills is not so good, too much time being occupied in changing the drills, and this part of the machine is frequently in need of repair.

Shots are being fired simultaneously by electricity, although the occurrence of stray defective fulminating caps causes annoyance. The Company intends laying a tramline down the hillside at an early date.

(*c*) The Hopetoun Reefs.

The property containing these reefs was taken up by a company of 100,000 £1 shares. It was known at first as the "Root Hog." Afterwards, various names, such as the Earl of Hopetoun and Lady Hopetoun, were given to different portions of the property. At present all the blocks constituting the old gold leases have been amalgamated into one property—The New England Scheelite Property.

The workings on the reefs are confined solely to the coarse granite area. The reefs approximate closely in both strike and dip to the more important lodes of the Hillgrove Gold-field. Of recent years the gold of the reefs has been found to give place, in patches, to masses of scheelite. In the upper portions of Nos. 1 and 2 lodes the scheelite was of very good quality. Mr. Fuller, of Hillgrove, informs me that at a depth of 300 feet below the surface a large body of low-grade lime tungstate has been exposed, in places as much as 3 feet wide.

Both gold and scheelite have been won by means of tunnels driven into the hillside.

No. 1 tunnel, 20 feet above the creek, bears 15° north of west and is 1,176 feet long. About 400 feet from the mouth of the tunnel No. 2 reef was cut. This has a strike of 35° north of west, and is thrown some 5 feet to the south by a cross course near the point of intersection with the tunnel.

A little further along Nos. 1 and 2 reefs have been stoped for a width of 20 feet, a height of about 50 feet, and a length of 60 feet. In the chamber so formed machinery was set up for the sinking of a main underlay shaft. At a depth of 30 feet the sinking was abandoned. No. 2 tunnel, 110 feet above the creek, cuts No. 2 reef some 50 feet from its mouth. The bearing of the reef here is 36° north of west. Here, also, a cross course has thrown the reef some 6 feet to the south.

No. 3 tunnel is driven on Nos. 1 and 2 lodes at a height of 170 feet above the creek bed. No. 4 tunnel is also driven on these lodes at a height of 220 feet above the creek.

Another vein, known as No. 3 lode, lies a little to the south of Nos. 1 and 2 lodes. Nos. 2 and 3 reefs are 15 feet apart in No. 2 level. The general dip of the reefs is north-east at 80°.

The early gold returns of this mine were supplied by Mr. S. Sullings, of Hillgrove.

The first four crushings yielded respectively 500, 400, 300, and 200 oz. of smelted gold.

(*d*) The Eleanora Reef.

The history of this mine has been outlined in the earlier pages of the report. Messrs. Brackin, Daly, and Elliot, having found the Eleanora in 1878, put in a claim for the Government reward offered for discovery of a payable mineral lode. At that time it was believed to contain antimony only. Reconstruction has been resorted to several times. The returns since 1890 show when reconstruction has taken place since that date.

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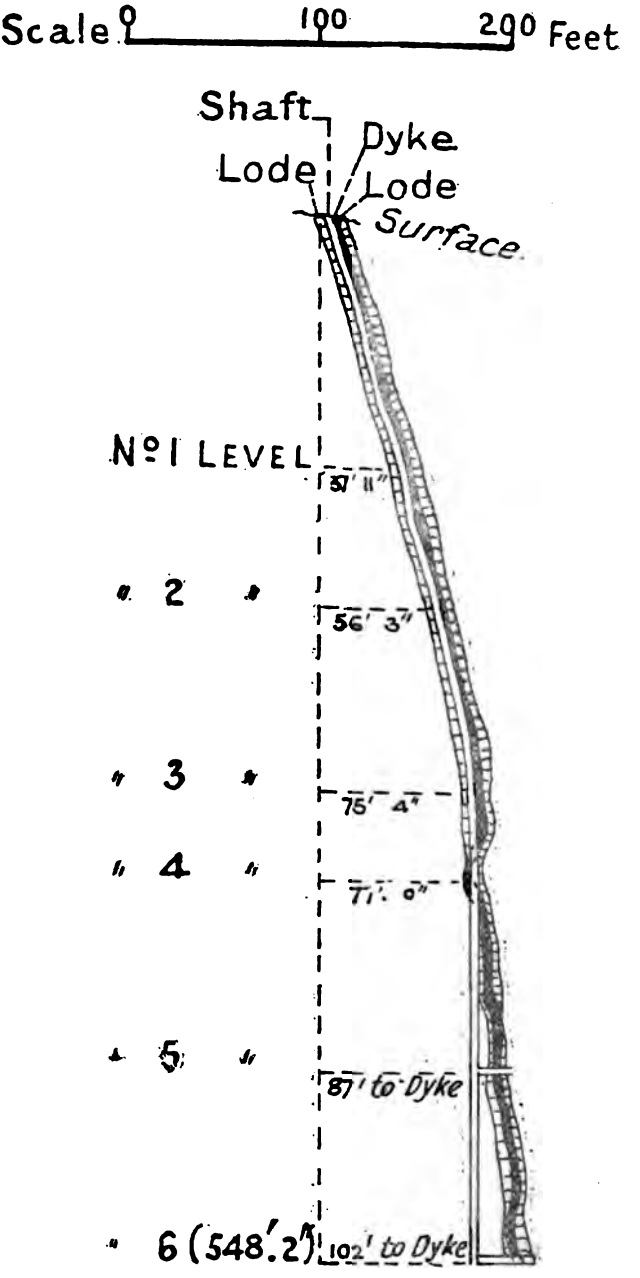
Section across lode, dyke, and shaft in southern (shaft) end of Eleanora Mine.



Between No. 6 and No. 5 levels and between No. 5 and No. 4 levels the dyke is bent, and the lode appears to sit on the bulged-out portion.

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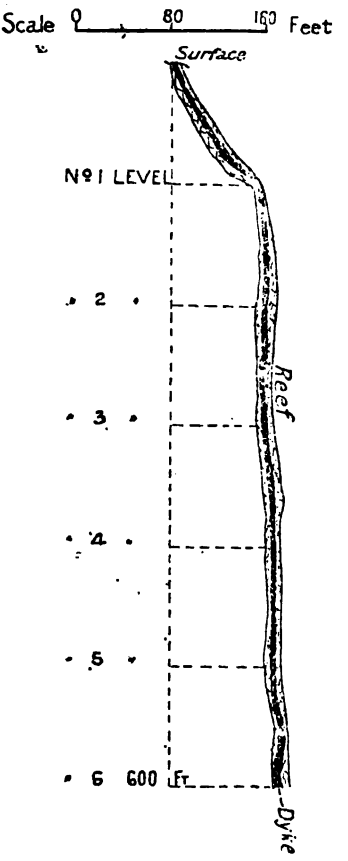
The Eleanora Reef, as also its southern extension, known as the Garibaldi, runs for the greater part of its length along the flat land at the top of the Baker's Creek gorge. It is the only important line of reef in the area that practically lies above the gully. Towards its northern end it runs diagonally along the face of the gorge till it passes into the coarse granite. Southwards it is continued over the point of the Garibaldi Spur, but does not appear to last as far as the greenish granite mass lying in that direction. Its strike is north-west and south-east approximately, and it possesses an underlay of

Section across Eleanora Reef towards Northern Boundary.



A brecciated slate lode, with white or transparent quartz cementing, heavily charged with arsenical pyrites, and containing vughs full of beautiful stibnite crystals. It is a huge low grade ore, as much as 23 feet wide in places. A metamorphosed granitic dyke occupies the central portion of the lode.

about 1 in 5 towards the north-east. If the Cosmopolitan Reefs are simply continuations of the Eleanora Reef, as appears probable, not only from their line of strike, &c., but quality of stone, as far as antimony is concerned, then this line of reef stands proven over one and a half miles of country. A granitic dyke, much altered, follows the lode along the greater part of its course, occupying the central portion of the lode.

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The country traversed is, for the most part, a slate, altered into a knotted schist. Numerous vughs occur throughout the lode, filled in places with magnificent stibnite crystals.

The returns show this reef to be a huge low-grade ore deposit. In places the stone is, with the included dyke, 22 feet wide. (*Vide* sketch of reef on page 20)

At first tunnels were driven on the lode from the side of the gorge. No. 4 is the lowest tunnel so driven. On the lip of the fall a whip-shaft was sunk on the reef. Afterwards the north shaft was put down to No. 4 level. This is an underlay shaft, and necessarily, as will be seen from sections of the lode, involves great strain on the hauling ropes. A south shaft was afterwards sunk, 200 yards from the north one, and at the No. 4 level both shafts were connected by a zigzag drive, which was generally carried along the reef. At the southern shaft the reef has been worked on both sides of the dyke, here about 4 feet wide. At times the total width of reef and dyke at this level is 10 feet. These shafts were then sunk vertically to No. 6 level. The south shaft is being carried down another 100 feet.* A reference to the vertical section of the Eleanora will show the amount of stoping performed in this mine (Plate XI).

No gold returns were obtained before June, 1892, but since that date they are as follows :—

Date.	Tons crushed.	Smelted Gold. oz.	dwt.	grs.	Antimony, &c.
July to 31st December, 1892.....	2,595	1,998	13	15	77½ tons crude antimony. 13¼ tons metal antimony.
January to 30th June, 1893	3,006	1,638	9	12	157 tons crude antimony.
July to 30th December, 1893.....	3,095	1,524	12	0	212 tons crude antimony.
January to 30th June, 1894.....	3,152	1,133	0	0	227 tons crude antimony. 86 tons concentrates.
July to 30th December, 1894.....	6,093	2,261	5	0	213 tons crude antimony. 88$\frac{1}{80}$ tons concentrates.
January to 30th June, 1895...	5,897	879	6	0	979 tons crude antimony. 37 tons metal antimony. 134 tons concentrates.
July to 30th December, 1895.....	6,305	2,010	6	0	186½ tons concentrates.
January to 30th June, 1896..... .	6,606	3,359	18	0	96½ tons crude antimony. 9$\frac{7}{20}$ tons metal antimony. 231 tons concentrates.
July to 30th December, 1896.....	6,847	4,696	7	0	211½ tons concentrates.
January to 30th June, 1897.....	6,230	2,506	7	0	9¼ tons crude antimony. 11$\frac{1}{20}$ tons metal antimony. 278 tons concentrates.
July to 30th December, 1897..... ..	6,180	2,826	1	0	298 tons concentrates.
January to 30th June, 1898..	1,879½	834	11	0	5$\frac{9}{10}$ tons crude antimony. 13$\frac{9}{10}$ tons metal antimony. 138 tons concentrates.
July to 30th December, 1898.....	6,260¾	2,674	8	0	3$\frac{9}{20}$ tons crude antimony. 1$\frac{3}{20}$ tons metal antimony. 230 tons concentrates.
January to December, 1899.....	220	104	11	0	270 tons concentrates.
	10,195	2,939	16	0	14½ tons oxidised antimony.

* The Eleanora has since been shut down.

The calcined concentrates yielded on an average 3 oz. 10 dwt. per ton, with a value of £3 10s. per oz.

The antimony oxide brought £16 10s. per ton on the field.

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To face page 32.

ELEANORA PLANT AND DAM, FROM THE EAST.

Plate V.

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Machinery.—The Eleanora workings supply a 70-head battery. A tramline some 200 or 300 yards in length (Plate V) connects the north shaft with the battery. The average weight of the stamps is 760 lb., with a drop of 9 inches, and an average working speed of eighty-five drops per minute. The method hitherto adopted has been to pass the crushed material over blankets, but copper plates are very shortly to be substituted. At present the battery contains 2,110 square feet of blankets and only 30 feet of copper plates. Nine "Berdans" are used for amalgamating. There are also two Arastras, and thirteen Frue vanners. The crushing efficiency of each stamp is 23 cwt. daily. The amount of calcined concentrates produced per day is 1½ ton. About 200 men are employed in this mine.

(*e*) The Garibaldi Property.

This line of reef is the south-east extension of the Eleanora or Isabella line of reef. As with the Eleanora, it was first worked for antimony and afterwards for gold.

In places two reefs, or two branches of the one reef, appear to have been worked. These lines are 20 feet apart. Two vertical shafts have been sunk, of which No. 2 shaft is 240 feet deep. From the shafts the lodes have been worked by crosscutting. There are three levels, viz., the 100, 140, and 240 feet levels.

The 100-foot level on one line of reef west of shaft has been driven 90 feet, and to the east has been taken 100 feet. The direction of this level is 5° south of east.

The 140-foot level is 190 feet in length, and is almost directly under the 100-foot level.

The 240-foot level has been reached by crosscutting 50 feet from the shaft. According to the plan of the workings the two reefs met with at the surface make into one at the 140-foot level.

The sections across the Eleanora Reef will answer equally well for the general features of the Garibaldi Lode, the dyke accompanying the central portion of the lode.

Twenty head of stamps were used in crushing the ore.

(*f*) The Cosmopolitan Reefs.

This property was originally taken up as the North and South Cosmopolitans. It consists of two reefs trending in a north-west direction and cut across by an east and west gully, which divides the North from the South Cosmopolitan. The reefs lie wholly in the coarse granite (granitite) of the field, and are held by the miners to be the northern continuation of the Eleanora Lode. There seems much to favour this idea, since sighting along the strike of the Eleanora as it makes down the gully, brings the hairline of the compass in line with the direction of the Cosmopolitan tunnels. The lode, however, has not been proved along the whole of this distance, an unproven patch of several hundred yards in length occurring to the south of the South Cosmopolitan. The talus of the hill slope may simply have obscured any possible outcrop however.

These lodes were pegged out in the same year as the Baker's Creek Reefs, and, though originally worked for gold, were subsequently exploited for antimony. The workings consist of several tunnels driven into the hill on the reef. These tunnels are 100 feet below each other. The lowest is 70 yards

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in length, driven in a north-west direction. The one immediately above is some 50 yards long, also driven in a north-west direction. The ore was brought to the tunnel-mouths and carried by tram up the sides of the hill. The underlay is to the north-east.

The South Cosmopolitans consist of tunnels driven in more than 100 feet into the hill. A heave has thrown one of these reefs 12 feet.

Many large parcels of antimony have been sent from this mine, one yielding 100 tons of metal.

From the Old and New Cosmopolitan Companies gold was obtained to the value of £31. From the "Old Cosmopolitan" £547 worth of antimony was extracted, and from the "New Cosmopolitan" £350 worth of the same metal was obtained.

(*g*) Carrington Line of Reef.

This is also thought by some to lie on the Eleanora line of reef, between the latter and the Cosmopolitans. The reef lies wholly in the coarse granite, and has produced much gold and antimony. Tunnels have been driven on the reefs. Formerly a large battery was in full working order on this side, while a fine dam for the conservation of water was constructed on the top of the falls 800 feet above the mine.

In 1886 this property was prospected by Mr. Thomas Snow, of Hillgrove. Tributors last year crushed 15 tons of stone for 31 ounces of gold.

(*h*) The Sunlight Reef.

The surface line of this reef is bold, and runs diagonally across the west side of the Baker's Creek gorge. (Plate VI.) The open cut is some 400 to 500 feet directly above the battery, while towards the West Sunlight it is 700 feet above the bed of the creek.

This property was first taken up by Moore, Speare, and Company about the year 1878 for antimony. Since that time the property has passed into various hands.

The general direction of the lode is 25° north of west. It runs fairly parallel to the outcrop of the latest granitic intrusion. The country is of slate and schist, much contorted and broken up by crushings and series of small faultings. The dip is about 1 in 5 in an easterly direction. The walls are better defined here than in the other reefs of the field. Magnificent crystals of stibnite (antimony sulphide) are found in vughs. From the surface to the No. 5 level the exploitation of the mine was carried on by means of short tunnels driven in from the hillsides. As the underlay is toward the creek, and the sides of the gorge are very steep, this method of winning the ore was comparatively easy.

No. 5 tunnel was driven in about 30 feet above the bed of the creek, and cut the reef 411 feet in the hill. No. 4 tunnel caught the reef at 240 feet, No. 3 at 70 feet, while the higher ones had tunnels driven on the lodes.

Short shafts were also sunk from the surface into the different levels.

On the No. 5 level the lode was worked east and west of the point at which the tunnel cut the reef. 500 feet along the lode in the western extension an underlay shaft was sunk, and from this Nos. 6, 7, and 8 levels are worked. The latter level is about 250 feet below the creek bed. The vertical section supplied shows the method of working the reef, and also the proximity of the granite along No. 5 tunnel. It must be remembered, however, that the large gold shoot of the reef is at some distance from the granite.

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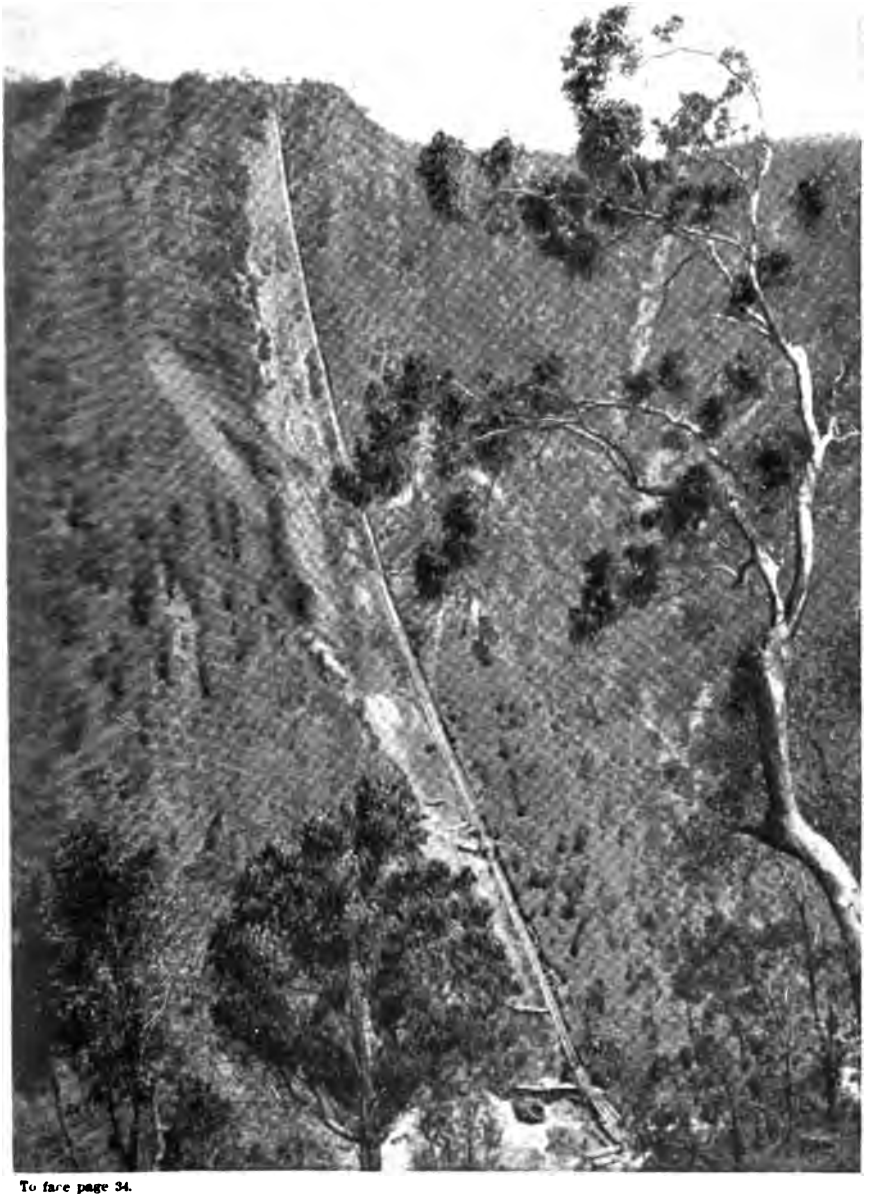

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SUNLIGHT TRAMWAY, SEEN FROM THE COONEY TUNNEL.

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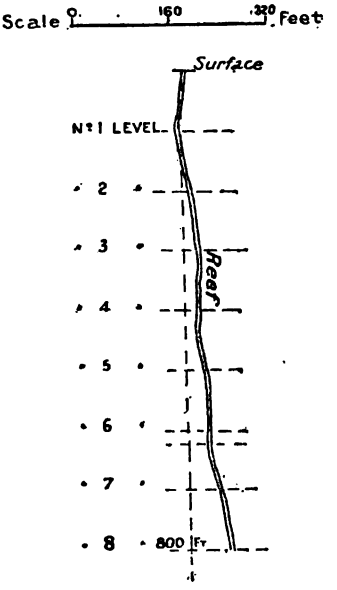
No plan is supplied of the stopings of this mine, but it may be interesting to know that most of the reef has been won in the western end as far down as the 7th level (800 feet). The stone has been much crushed in this lode, and huge masses continually threaten to fall during the progress of overhand stoping. From No. 7 to No. 6 level the reef is being won by stoping in a diagonal direction.

Sunlight Reef.—Section at western end.



Down to No. 5 level the ore has been won by tunnels and a series of short shafts on the hillside. 950 feet along the No. 5 tunnel and drive an underlay shaft has been sunk on the lode.

At the eastern end the lode has been much faulted, but no trouble has been exercised to pick it up, as the stone is of inferior quality. Still, much of the reef has been extracted as low down as No. 5 level. In all, five shoots of stone are said to exist in the mine, each of which is more or less vertical.

No returns of the Sunlight Mine were available before 1892. From that date onward they are as follows :—

Date.	Tons crushed.	Ounces Smelted Gold.
		oz. dwt. grs.
1892 }	7,820	4,029 1 0
1893 }		667 10 0
January to December 30th, 1894 (partial return)	3,459	1,337 3 0
January to December 30th—		
1895	10,688	4,838 12 0
1896	13,248	7,927 12 0
1897	11,248	5,326 12 0
1898	10,997	4,598 9 0
1899	9,567	4,722 5 0

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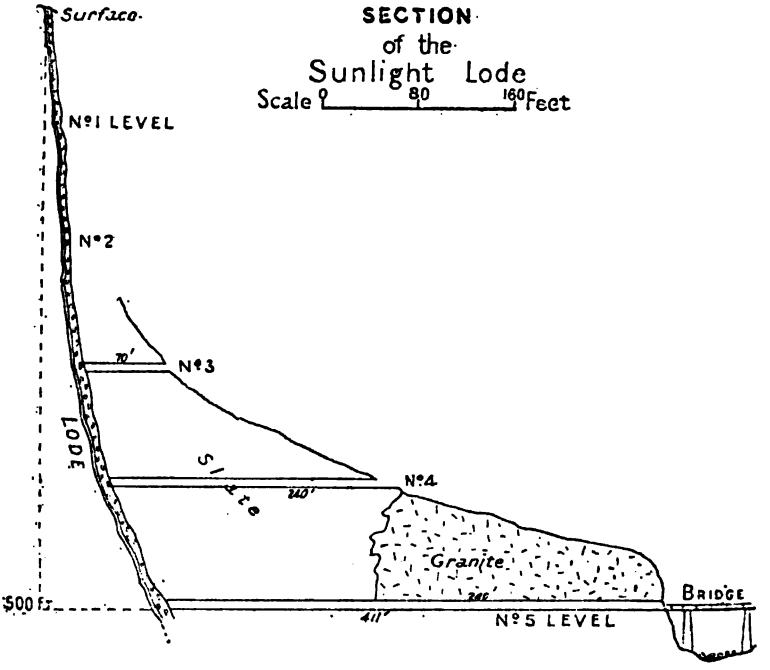
Sunlight Lode.



The lode is quartz and slate breccia, containing much antimony and arsenical pyrites. The lode has been reopened, and the later fissure filled with crushed slate. This disturbance seems traceable to the intrusion of the fine granite at A. The proximity of the granite to the lode will at once be observed. The plan represents the projection of the tunnels on to one vertical plane.

Total amount of quartz crushed from 1st January, 1892, to 30th December, 1899, is 75,085 tons for a yield of 36,873 oz. 6 dwt. 12 grs. of smelted gold.

The machinery consists of forty head of stampers, each averaging some 650 lbs. in weight. These, with a fall of 8 inches, working up to seventy-five blows per minute, assisted by a Blake-Marsden type of rock-breaker, and with automatic feeders, gives a result of 430 to 500 tons crushed per fortnight, or an average working efficiency for each stamp of 18 to 20 cwt. per day. The crushed ore passes from the stampers over 16 feet of copper plates, and the thick pulp from the settling boxes is placed on Frue vanners, each of which is served by five head of stamps.

The mine is lighted by electricity, and the lower levels of the mine were also, until very recently, worked by an electric plant stationed at the top of the main shaft in No. 5 level.

(*i*) West Sunlight Mine.

The work done by this Company consists in the exploitation of the north-west continuation of the Sunlight line of reef. Two reefs were worked, the Magazine and the West Sunlight or Main Reef. The strike of the reef at the boundary between the Sunlight and West Sunlight properties is 20° north of west, and the lode has been proved for 800 feet in this direction. Traces of it exist in the rough country to the north-west, but no payable prospects have been obtained.

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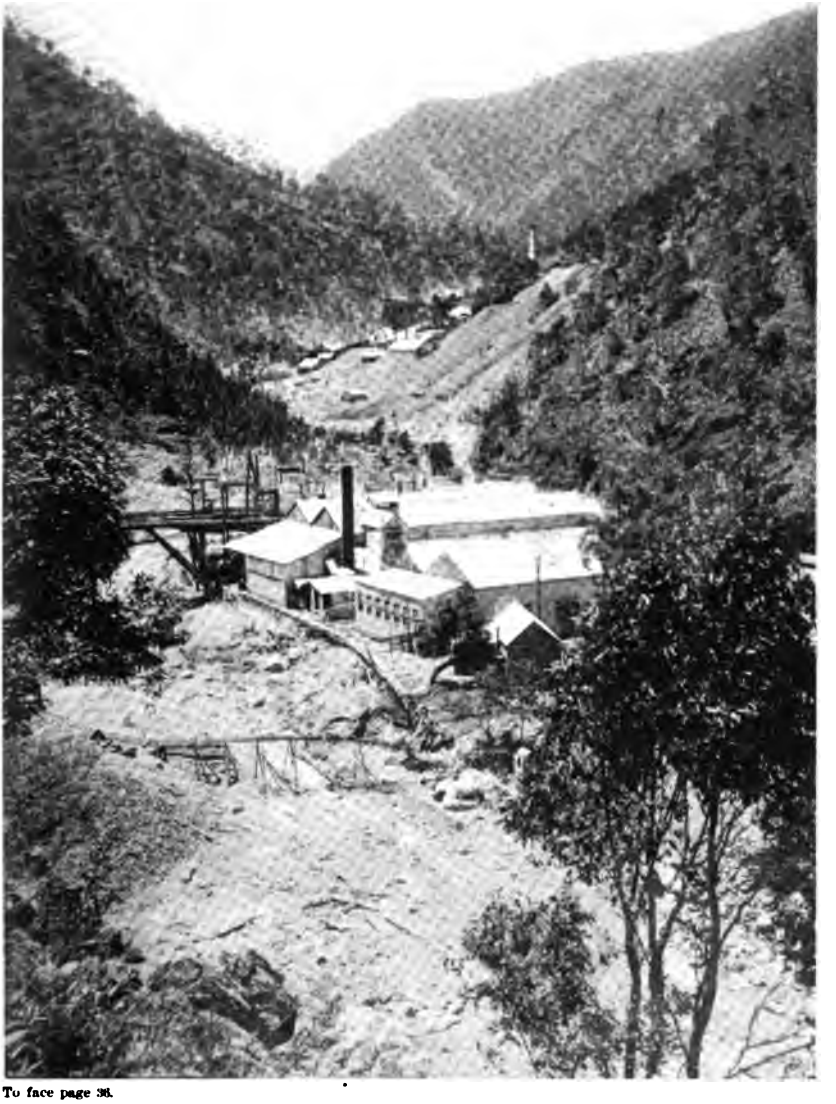

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SUNLIGHT BATTERY, WITH CONSOLS AND BAKER'S CREEK WORKINGS IN THE MIDDLE GROUND.

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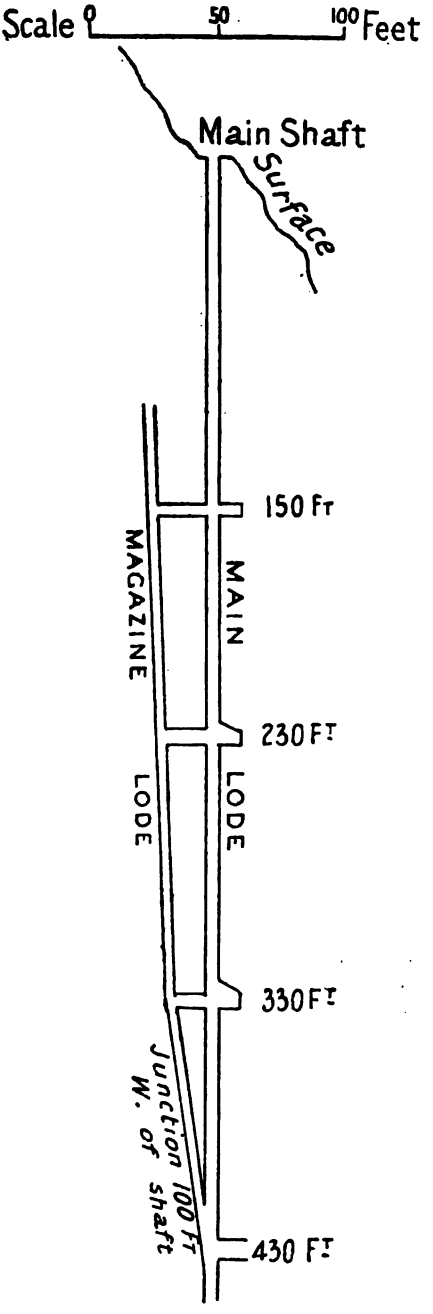
Section across Magazine and Main Lodes of the West Sunlight Property, showing the bifurcation of main lode at 430-foot level, and the method of winning the ore from the Magazine lode.



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The Magazine and Main Reefs were worked simultaneously from a main shaft, crosscuts being driven from the main line to work the Magazine Reef. At the 430-foot level the two reefs made into one. In all ten levels have been driven. No complete plan of the workings was obtainable. The cross-section shows the relative position of the two reefs, and the methods adopted for winning the ore. A good deal of stoping has been done, particularly between the surface and No. 5 level. Mining operations have been at a standstill during the past half-year (July to December, 1899). McNamara and Party expect to resume work early this year.

The following gold returns of the mine between January, 1894, and June, 1899, were supplied by Mr. McNamara, of Metz :—

Date.	Tons crushed.	Ounces Smelted Gold.	
		oz.	dwt.
January to June, 1894	4,614	2,546	19
July to December, 1894	4,943	2,479	13
January to June, 1895	3,792	1,659	10
October to December, 1895*	2,064	795	16
January to June, 1896	3,621	1,541	6
July to December, 1896	3,949	2,019	8
January to June, 1897	3,419	1,660	18
July to December, 1897	3,773	2,441	3
January to June, 1898	4,646	1,900	12
July to December, 1898	3,835	1,204	19
January to June, 1899	2,082	750	7

* Mine closed July to October, 1895, owing to want of water.

In 1898, 119 tons 13 cwt. of concentrates were treated for 583 oz. 12 dwt. of gold. Twenty head of stampers were in use, each stamper weighing about 900 lb.

(*j*) Baker's Creek Reefs.

Baker's Creek property includes the most valuable portions of the Little Reef, the Big Reef, the Middle Reef, and Hill's Reef. These are situate in the lower portion of the eastern side of the gorge. By a mere accident the Little Reef was included in the area pegged out for the Big Reef, and as it underlay into the portion, the wealth of the property was assured. Since the initiation of mining operations on this property the Company holding it have regularly paid dividends.

The general trends of the reefs are as follows :—

The Little Reef	N. 55° W.	
The Big Reef	N. 50° W.	All dip easterly
Hill's Reef	N. 30° W.	at about 75.°
The Middle Reef	N. 65° W.	

The Big Reef outcropped strongly in one or two places at the surface, showing a body of stone 4 feet wide. But for some distance down it contained very little gold, and much of it in the higher levels was never stoped.

The Little Reef is marked in places by its thread or "stringer"-like appearance, and its lack of well-defined walls. The payable part of the lode in the Little Reef is confined to a steep shoot of stone. According to the underground managers, this has been worked from the No. 3 level to the lowest point yet attained in the mine, viz., the 13th level. In a straight line No. 1 cross-course is about 120 feet distant from the main shaft, while No. 2 cross-course is generally some 200 feet nearer the southern boundary. The

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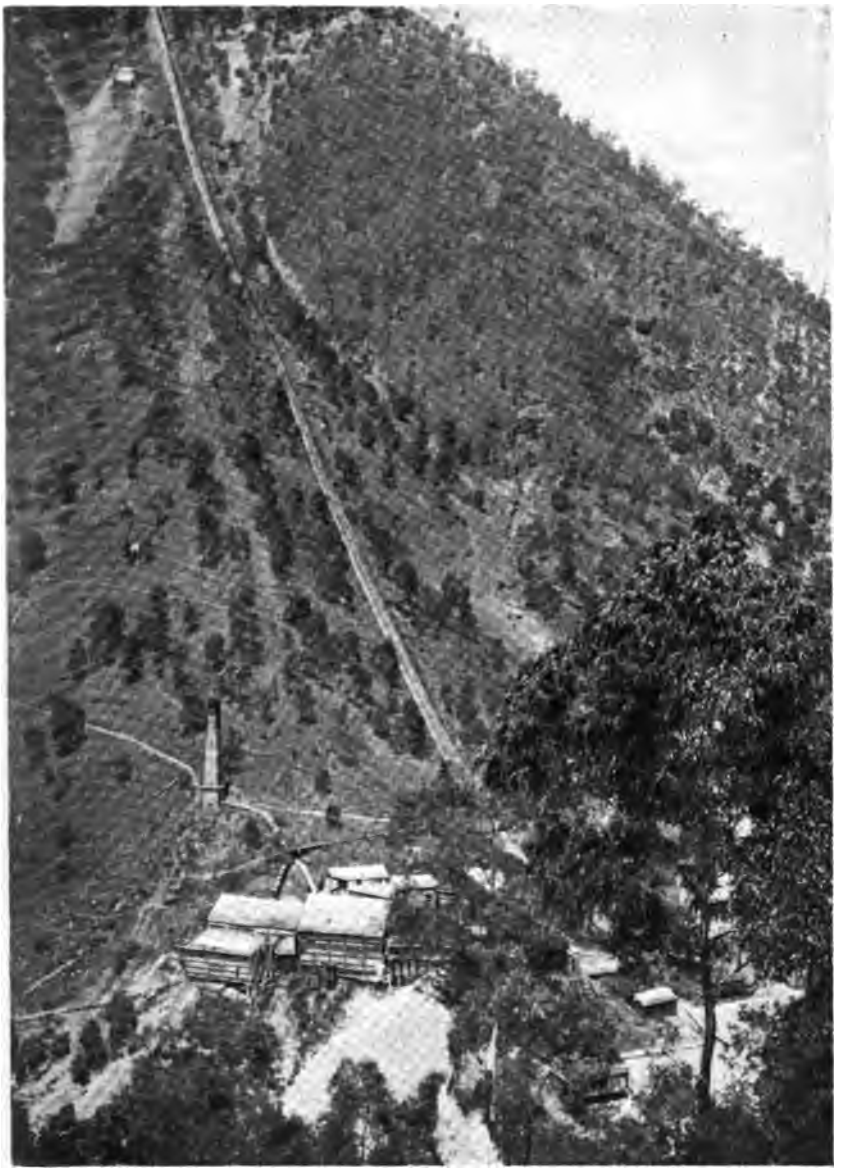

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BAKER'S CREEK TRAMWAY, FROM PETERSEN'S SHAFT.

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north-west boundary of the shoot is close to No. 1 cross-course. The best gold in the upper levels was contained between the two cross-courses. At No. 7 level the gold was found thickly scattered about in No. 1 cross course; thence downwards it was obtained further to the south, and the shoot possessed a steep angle of dip. At No. 9 level the southern extension of the shoot was 53 feet from the end of the drive, 112 feet from No. 2 cross-course, and 418 feet from No. 1 cross-course. The shoot at this level was 40 feet wide.

At No. 10 level the southern boundary of the shoot was 40 feet from the end of the drive (more than 60 feet from boundary). The shoot itself was 40 feet wide, and was 163 feet from No. 2 cross-course.

Similar results were obtained in Nos. 11 and 12 levels. At No. 12 the southern boundary of the shoot was 90 feet from the southern boundary of the property.

The ore was won in the early days of the field by open cuts along the outcrops of the reefs. Good work was hampered considerably by the amount of surface debris (*see* longitudinal section, Plates XII and XIII), which at times amounted to as much as 50 feet in thickness. No. 4 tunnel was driven in on the reef near the bed of the creek. At the mouth of No. 3 level, a main shaft was sunk, and from this most of the reef has been worked. The shaft follows the reef to No. 6 level, and thence to No. 13 the ore has been won by cross-cutting from the shaft, which latter, though not vertical, does not follow the reef. The Big Reef has been worked below No. 3 level by cross-cutting from the corresponding levels on the Little Reef, on No. 1 cross-course. (*See* section across Big and Little Reefs, Plate XIV).

A shaft was put down to the north of the main one (at the entrance to No. 3 level), and levels at 125 and 225 feet respectively were driven along the Little Reef. The 225 feet level is nearly on a level with No. 6 in the main workings.

One of the difficulties in working the Little Reef is the apparent insignificance of the vein. Frequently it traverses the dense blue slate country as a mere ribbon, and unremunerative veins setting out from it frequently make into strong reefs up to 12 inches or 18 inches wide. Another is the difficulty attendant on working the "kicking" ground along certain levels. Certain parts of the reef, notably at No. 11 level, are unstoped, as the risk to the men's lives working the ground is considered too great to continue the work.

A tramway has been laid down from the top to within 50 feet of the bottom of the gorge (Plate VIII). Its course is perfectly straight, and the line itself is triple, with a central loop. Sleepers are fitted into the slope of the hill some 2 feet apart. The length of the line is 2,660 feet; the vertical descent is 1,407 feet, and the steepest angle of slope 43 degrees. An endless rope, $\frac{7}{8}$-inch in diameter, and 3,000 feet long, is in use for hauling the trucks. Its breaking strain is 22 tons, and its usual load, including the truck, never exceeds two tons. Formerly the men were compelled to walk up and down the hill-side to their work, but for some years past now the trucks have been utilised partly for this purpose. The men subscribe a certain proportion of their wages to an accident fund, and in case of a mishap, the injured ones receive attendance at the local hospital, and certain pecuniary assistance while incapacitated for work.

Machinery.—The company owns a fairly complete plant for crushing ore. The battery consists of 40 head of stampers, each averaging some 6 cwt., and having a fall of 6 or 7 inches. Their working speed is ninety to ninety-five blows per minute. Automatic feeders are in use, but the ore is broken up small enough in the stopes to dispense with a rock-breaker. Each stamper serves 7 feet of copper plates, and 20 feet of blankets per medium of slotted

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screens; four Woodbury vanners and two large Berdan pans, each 4 feet in diameter, save the concentrates. About 500 tons of stone are put through every fortnight, each stamp thus possessing a working efficiency of 18 cwt. per day. The shoes of the stampers, as well as other rough ironwork, are cast on the premises.

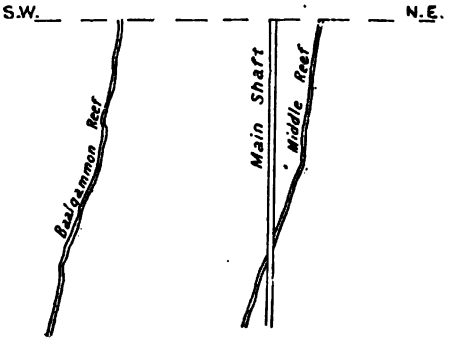
The following are the returns for the Baker's Creek Mine, with a few exceptions, from 1887, the year of discovery, up till the present :—

Date.	Tons of stone crushed.	Ounces of smelted gold.
		oz. dwt.
November 12th—December 24th, 1887	63	700 0
May 9th—December 27th, 1888	766	8,959 0
January 21st—June 29th, 1889	1,307	17,293 0
January 31st—June 28th, 1890	2,613	5,836 10
July 7th—December 31st, 1890	3,111	5,639 0
January 30th—June 30th, 1891	3,005	7,575 16
July 17th—December 24th, 1891...	3,121	10,500 0
February 26th—June 30th, 1892...	3,996	6,975 0
July 15th—December 23rd, 1892...	4,551	11,564 8
January 24th—June 30th, 1893	4,779	9,748 12
July 15th—December 23rd, 1893..	4,958	10,337 12
January 18th—July 10th, 1894	5,251	8,675 16
July 14th—December 23rd, 1894	5,677	8,918 12
January 26th—June 29th, 1895	6,710	8,194 2
July 13th—December 24th, 1895...	7,048	7,610 11
January 25th—June 30th, 1896	7,741	7,238 18
July 10th—December 30th, 1896...	5,354	5,278 13
July 23rd—December 24th, 1897...	6,809	5,933 10
January 21st—June 30th, 1898	6,563	5,131 15
July 29th—December 24th, 1898...	5,977	4,910 6
January 30th—June 30th, 1899	6,818½	6,642 0
July 1st—December 30th, 1899	6,368	6,474 13

(*k*) The Consols Reefs.

The reefs worked by the company owning this property are portions of the Little, Middle, and Baalgammon Reefs (Plate IX). The outcrop of the Middle

Section across Consols Property.



reef lies on the eastern side of the creek bed. Its strike varies from 20° to 25° east of south. It intersects the Little Reef immediately beneath the Baker's Creek assay office.

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To face page 40

CONSOLS MACHINERY AND MINE.

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The diagram represents a section across the Middle and Baalgammon Reefs on the Hillgrove side of the creek. Since September last, the company have sunk the main shaft vertically from the 200 to the 300 feet level. After driving for a short distance on the Little Reef, below and beyond the creek bed, and cross cutting in a westerly direction, a fine-grained granite was met with, in which the reef died away in so-called "stringers," or ribbons of quartz. The north-west extension of the Little Reef is not so productive as the portion worked by the Baker's Creek Company. The Middle Reef yields the best stone.

Since September, 1897, this mine has yielded 3,550 oz. 12 dwt. of smelted gold, the result of crushing 4,497 tons of ore.

(*l*) Starlight Reef.

The property containing this reef lies wholly within the coarse granite area, near the Hopetoun Mine. The workings on the reef consist of two tunnels driven in on the lode a little above the bed of Baker's Creek. The strike of the Starlight Reef approximates to an east and west direction.

The lower tunnel has been driven 230 feet into the hill, while the second and higher level has had a winze sunk on it for 60 feet. The ore body fluctuates in size, varying from a mere line to 15 inches in width.

In 1889,	7	tons	10	cwt.	of stone were crushed for a yield of				32	oz.	11	dwt.	0 gr.
„ 1890,	47	„	16	„	yielded	...	...	...	83	„	14	„	0 „
„ 1894,	9	„	15	„	„	...	...	...	25	„	16	„	0 „
„ 1895,	65	„	15	„	„	...	...	...	140	„	1	„	12 „
„ 1896,	4	„	2	„	„	...	...	...	11	„	15	„	0 „
Total...	134	tons	18	cwt	for	...	...	...	293	oz.	17	dwt.	12 gr.

Giving an average of over 2 oz of gold per ton of ore crushed.

(*m*) The Sandon Electric Light and Power Company.

This company has almost completed a large dam, on the "anchor crib" weir systen, near the Gara River Falls, 5 or 6 miles distant from Hillgrove. Mr. F. Cotton, M.P., is constructing this dam for the conservation of water, wherewith to drive the mine batteries, and serve the township with the electric light. The dam has an extreme length of 575 feet, a width at the base of 90 feet, tapering to 20 feet wide on top. The construction is of log-cribbing, resting on a granite foundation; the interstices in the cribbing being packed with gravel and clay. A sheet of water several miles long has been conserved. The minimum supply of water in the dam is said to be 350,000,000 gallons. One and a quarter mile of Oregon pine fluming, 2 feet deep, will conduct the water to an iron pipe 900 feet long, set at an angle of 45 degrees, thereby giving a head of 450 feet. The nozzles coming from the pipe are arranged so as to pour the water on to Pelton wheels, each the equivalent of 300 horse-power. With a loss of 20 per cent. the company expects to deliver 1,000 h.-p. to the batteries through 5 miles of wire.

This company has already lighted up the town by electricity, borrowing the Garibaldi steam-engine until such time as the dam shall be completed.

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(*n*) Paradise and No. 9 Antimony Lodes.

At the head of Swamp Creek, two large antimony reefs occur, about 60 feet apart, and underlaying slightly toward each other. Traced down the bluffs of the creek head (Plate III), the Paradise lode is seen to turn off at right-angles and cross the bed of the creek. Close on 2,000 tons of antimony have been extracted from these lines of reef.

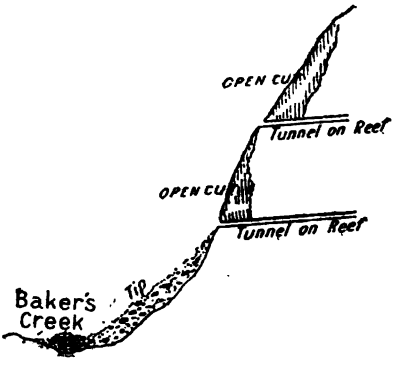
(*o*) Murgatroyd's Tunnel.

This tunnel has been driven 552 feet into the hill just below the Cooney tunnel, and on the Metz side of the gorge, at a cost of about £3,000. This includes also a cross-cut east and west from the tunnel. 188 feet from the entrance of the tunnel a tongue of crushed granite 28 feet wide was cut through, while the end of the tunnel is carried through another granite apophysis. 270 feet from the entrance a formation of yellow crushed slate occurs having a strike of south 27° east, and a dip of 80° to the north-east. It is claimed that this formation is the south-east extension of the Sunlight Reef. A winze has been sunk 30 feet in the cross-cut, and Mr. Murgatroyd intends carrying this down 200 feet. The country is much crushed and faulted.

(*p*) Minor Properties.

The Baalgammon Reef.—The general trend of this vein is north 55° west, with a high general angle of dip in a north-east direction. It thus corresponds closely in strike and dip with its neighbour—the Little Reef.

Sketch illustrating method of working the Baalgammon Reef.



Above the Consols property, the Baalgammon stone has been won by a set of three tunnels driven in on the outcrop of the lode. It was pegged in by Jensen, Maddricks, and Party in 1891. Among various parcels of stone crushed were :—

18	tons	of	ore	for a yield of	35	oz. 11	dwt. of gold.
2	,,	,,		,,	7	,, 14	,, ,,
3	,,	,,		,,	3	,, 6	,, ,,

the latter quantity being raised by tributors. This was in the upper levels. Prospectors working on a supposed lower level on the reef never met with

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any payable stone. Aid was procured to cross-cut for a distance of 200 feet from the lowest tunnel; but the applicants availed themselves of the aid for 60 feet only.

Trimm's Tunnel, Mount Carrington Gold-mining Company's Tunnel, and Beiber's Tunnel have been driven into the hill to prove the continuation of certain well-known reefs. Of these, Trimm's Tunnel lies between Murgatroyd's Tunnel and the Sunlight Lode. It has been driven through the formation that crosses Murgatroyd's Tunnel, but there is nothing definite to be seen owing to intense crushing of the country. The other two tunnels were driven to pick up the southern extension of the Little Reef.

Keyes' Scheelite lies completely in the coarser granitite area. It has been proved for a distance of 320 feet along the lip of the Baker's Creek Falls. It varies from 1 inch to 4 inches in width, and occurs in lenticular patches. Much of the ore won is found to contain over 60 per cent. of tungstic acid. From this lode and another but smaller one lower down the hill, 20 tons were raised during the last year.

Maddrick's Scheelite.—This property lies on the west side, and about halfway up the Baker's Creek gully. It contains some pure scheelite. Seventeen tons were raised during the last half year.

Brackin's Spur and Beck's Antimony Lode are two other localities from which considerable quantities of antimony have been raised from time to time.

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DESCRIPTION OF PLATES.

Frontispiece. Panoramic view of Baker's Creek plant.

II. Whittaker's Spur, seen from the south.

III. Slate and Granite Bluff—Head of Swamp Creek.

IV. View of Baker's Creek Gorge from Campbell's Spur.

V. Eleanora plant, from the east.

VI. Sunlight Tramway. The Tramway crosses the reef.

VII. View of Sunlight Battery, with Baker's Creek Battery in middle ground, and Cosmopolitan in distance.

VIII. Baker's Creek tramway.

IX. Consol's Battery and poppetheads.

X. Micro-photograph, taken under crossed Nicols, illustrating the faulting of felspars in the green basic variety of granite.

XI. Section of Eleanora workings.

XII. Section of Little Reef, showing amount of stoping.

XIII. Section of Big Reef, showing amount of stoping.

XIV. Section across Big and Little Reefs.

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Plate X.

To face page 44.

MICROPHOTOGRAPH, ILLUSTRATING FAULTING OF FELSPARS.

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SECTION

ELEANORA GOLD AND ANTIMONY MINE

Horizontal and Vertical Scale 0 100 200 Feet

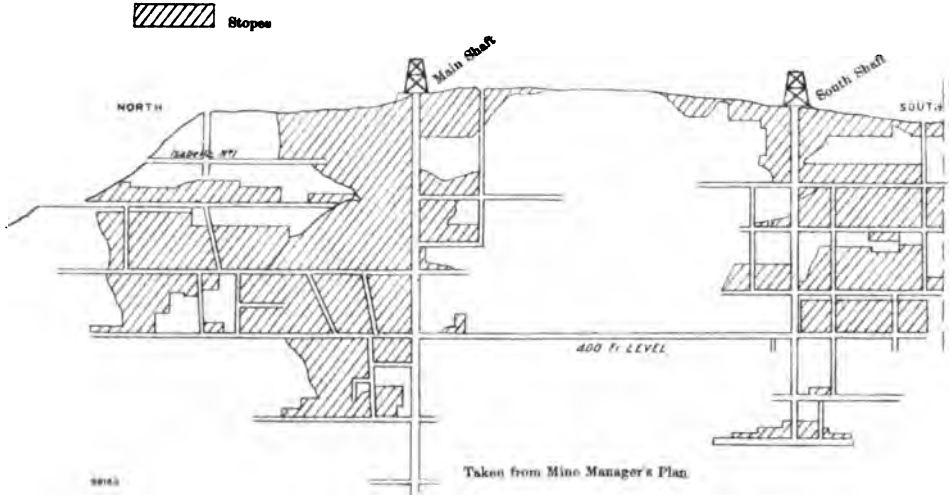

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Plate XI.

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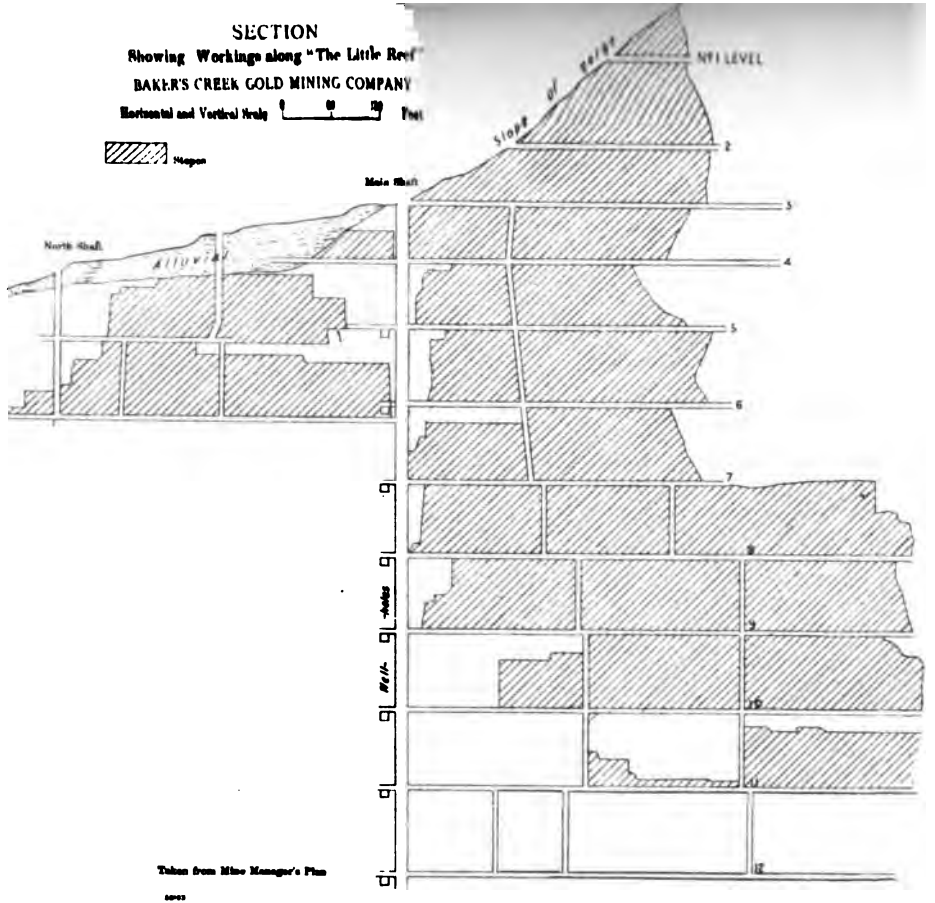

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Plate XII.

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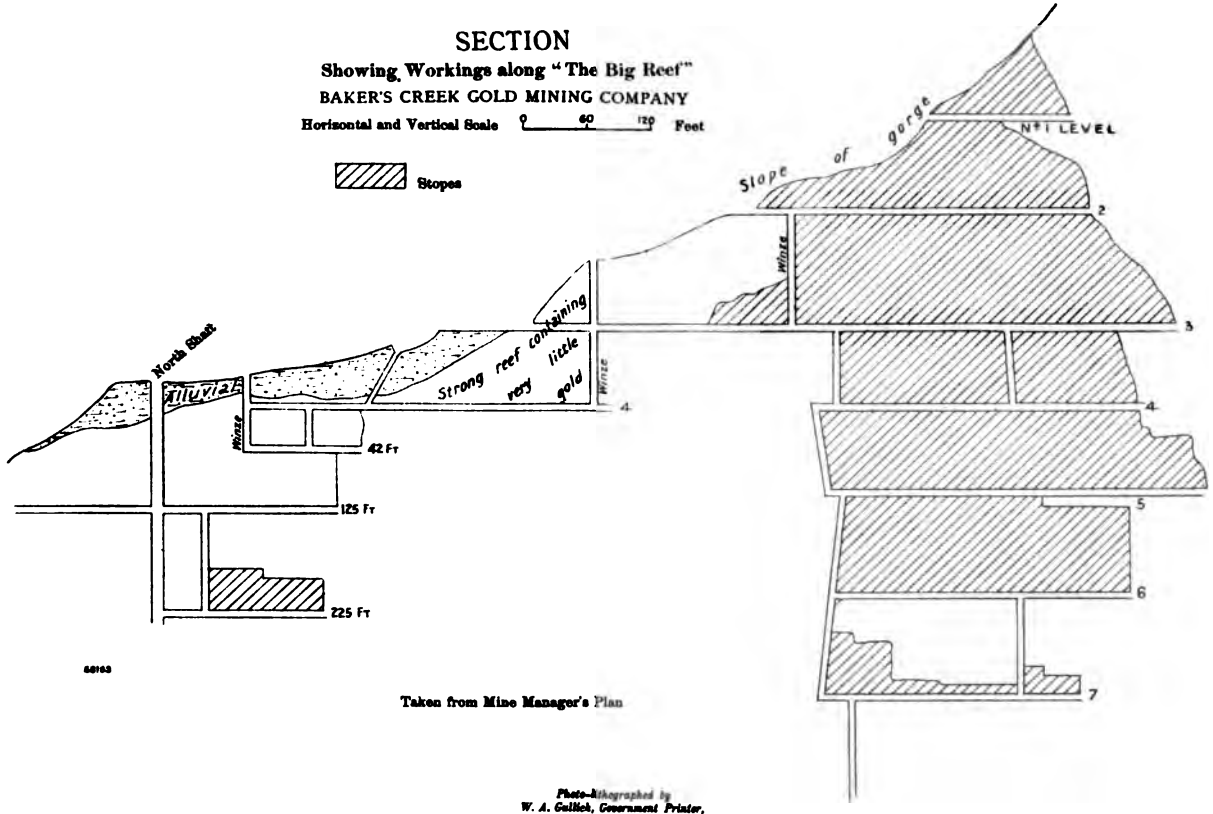
SECTION

Showing Workings along "The Big Reef"

BAKER'S CREEK GOLD MINING COMPANY

Horizontal and Vertical Scale 0 60 120 Feet



Taken from Mine Manager's Plan

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Plate XIII.

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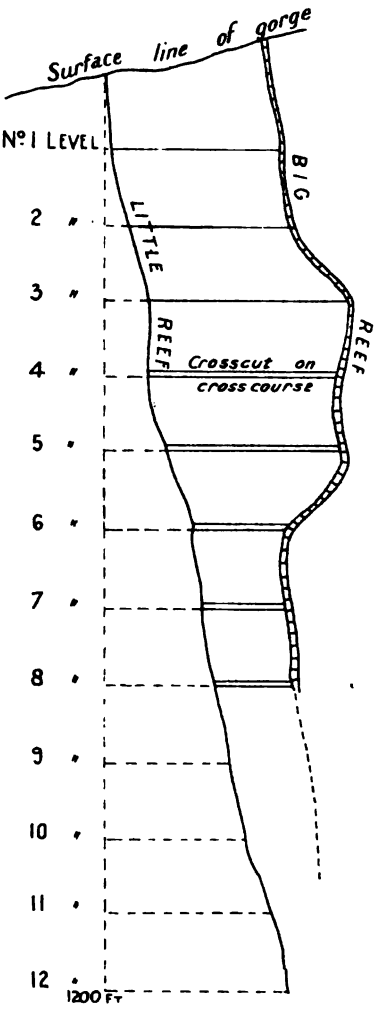
SECTION
OF THE
Big and Little Reefs
Scale 0 100 200 Feet



The main shaft is sunk on the "Little Reef" and the ore from the "Big Reef" is won by means of crosscuts driven on a crosscourse from the "Little" to the "Big Reef."

The crosscuts are projected into one vertical plane.

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VIEW OF YALWAL FROM THE SOUTH.

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NEW SOUTH WALES.

DEPARTMENT OF MINES AND AGRICULTURE.

GEOLOGICAL SURVEY.

E. F. PITTMAN, A.R.S.M., GOVERNMENT GEOLOGIST.

MINERAL RESOURCES.

No. 9.

REPORT

ON THE

YALWAL GOLD-FIELD.

BY

E. C. ANDREWS, B.A.,

GEOLOGICAL SURVEYOR.

1901.

SYDNEY : WILLIAM APPLEGATE GULLICK, GOVERNMENT PRINTER.

1901.

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Geological Survey Office,
Department of Mines and Agriculture,
Sydney, 17 October, 1901.

Sir,

I have the honor to submit for publication Report No. 9 of the Mineral Resources Series, being a description of the geology of the Yalwal Gold-field, by Mr. E. C. Andrews, B.A., Geological Surveyor.

Gold-mining operations have been carried on at Yalwal for about thirty years, and although some extremely rich patches of stone have been extracted from such mines as The Pinnacle, The Caledonia, The Pioneer, and The Homeward Bound, it is chiefly upon the low grade ores of the field that the gold-mining industry has had to depend.

The Yalwal field is of interest, owing to the fact that the mining and treatment of auriferous ores has been effected here at a lower cost than in any other part of the State; one of the principal reasons for this is that the ore can be extracted in open cuts or quarries at a very low rate. The gold occurs chiefly as impregnations in indurated slates, quartzites, and conglomerates of Devonian age, and although minute quartz veins are occasionally visible in these, it is found to be more economical to extract and treat the whole of the material rather than to attempt to pick out the richer portions.

The Homeward Bound and Pioneer Mines have been able to pay their way for some years by treating ore of exceptionally low value; and in view of this fact it seems probable that good profits could be obtained if these mines were worked on a much larger scale, as is done, for instance, with analogous ores at the Treadwell mine, Alaska, U.S.A.

EDWARD F. PITTMAN,
Government Geologist.

The Under Secretary for Mines and Agriculture.

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SYNOPSIS OF CONTENTS.

FRONTISPIECE.

1. INTRODUCTION.

2. SYNOPSIS OF CONTENTS.

3. HISTORY OF DEVELOPMENT OF MINING :—
   Report by A. Mackay in 1852.
   Reports by Rev. W. B. Clarke, F.R.S., 1860–72 :—Sluicing operations by J. Sivewright and Party. Inception of operations at Pinnacle and Eclipse Claims. Alluvial gold found in Sawpit Gully, 1871. Discovery of Pioneer Claim, 1872. Homward Bound Mine, 1874. Erection of batteries. Find of alluvial in Sawpit Gully, 1893. Caledonian rich finds, 1895. Payable gold prospects at Grassy Gully, 1895. Summary.

4. PREVIOUS REFERENCES TO YALWAL GOLD-FIELD :—
   (*a*) A. Mackay. (*b*) W. B. Clarke. (*c*) E. F. Pittman. (*d*) J. B. Jaquet. (*e*) Wardens' Reports.

5. PHYSICAL GEOGRAPHY :—
   Mountain and river systems. Scenic features determined by slope of strata and nature of rocks. Meteorology.

6. GENERAL GEOLOGY :—
   A. Upper Marine Sandstones.
   Carboniferous—Granites and porphyries.
   Devonian — Lepidodendron Beds. Sills and contemporaneous flows. Gold-bearing rocks. Rhyolites.
   B. The Sedimentary Rocks—(*a*) Upper Marine sandstones. (*b*) Devonian.
   C. Eruptive Rocks.—(*a*) Rhyolites. (*b*) Dolerites. (*c*) Granites and porphyries.
   D. Metamorphism.
   E. Petrology.

7. ECONOMIC GEOLOGY :
   (*a*) Alluvial Mining. (*b*) Occurrence of gold at Yalwal and Grassy Gully. (*c*) Other mineral occurrences.

8. DESCRIPTION OF MINING PROPERTIES :—
   A. Yalwal — (*a*) Pinnacle. (*b*) Eclipse. (*c*) Pioneer. (*d*) Homeward Bound. (*e*) Caledonian. (*f*) Star. (*g*) Golden Crown. (*h*) Usher. (*i*) Golden Quarry (Nos. 1 & 2). (*j*) Victory. (*k*) Poor Man. (*l*) Minor properties.
   B. Grassy Gully—(*a*) Grassy Gully Mine. (*b*) Percival's Claim.

9. APPENDICES.

10. DESCRIPTION OF PLATES.

PREVIOUS REFERENCES TO THE YALWAL AND GRASSY GULLY GOLD-FIELDS.

(1.) In 1852, Mr. A. Mackay, Commissioner of Crown Lands, reported on the geology of Yalwal.*

(2.) The Rev. W. B. Clarke, F.R.S., also reported on the Yalwal Gold-field at various times between 1860 and 1872.†

(3.) Mr. E. F. Pittman, Government, Government Geologist in 1883, made a report also on the Yalwal field ‡

(4.) Mr. J. B. Jaquet, Geological Surveyor, reported on a gold-bearing rhyolite at Grassy Gully.§

(5.) Mr. W. H. J. Slee, Chief Mining Inspector, reported on the Bundundah reefs.‖

(6.) Various Wardens' reports are to be found in the Annual Reports of the Depart, ment of Mines for the years 1878–79, 1880–81, 1887–88, 1888–89, 1889–90-1890–91, 1891–92.

---

* Southern Gold-fields, pp. 39 and 40. † *Ibid.*, pp. 40–45. ‡ Ann. Rept., Dept. Mines for 1883-84 pp. 159 and 160. § Records Geol. Survey N. S. Wales, 1900, vii. p. 17. ‖ Ann. Rept., Dept. Mines, N. S. Wales, for 1889, p. 134.

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INTRODUCTION.

MANY of the gold bearing areas in New South Wales are closely connected with granite masses of Carboniferous age.

The main mountain makers of the Cordillera of New South Wales (as also of Queensland) are Carboniferous rocks of basic granite types, and the auriferous areas skirting these masses are more or less dependent on them for their gold supply.*

The gold may be contained in the granite or felsite itself; it may exist throughout the contiguous strata in veins caused by intrusion of the igneous masses, and subsequently filled by circulating mineralised waters; or the gold, under the influence of the igneous masses, may be segregated from the strata themselves into veins or pockets.

Yalwal and Grassy Gully appear to be additional examples of this influence of Carboniferous (?) granitic masses.

In Yalwal itself, the gold, though not mined for in the granite, is yet in such association with it as to suggest its influence.

At Grassy Gully, five miles north of Yalwal, the gold-bearing reefs are contained in an old rhyolite, which exhibits traces of flow structure.†

The rough and mountainous character of the country made Yalwal difficult of access in former times. Even at present the road down the mountain leading to the township contains a grade of 1 in 4½ near the summit. A new road, with a grade of 1 in 12, is almost completed, and this will benefit the Nowra-Yalwal traffic considerably.

Hitherto Grassy Gully has been heavily handicapped for the same reason, although a new road, almost completed to Burrier, will give the residents access to the outer world. All these means of communication with Nowra will make for progress in this district.

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* Address delivered to Royal Society of N. S. Wales, September, 1900, by Prof. T. W. E. David, F.R.S.
† J. B. Jaquet, Records Geol. Survey, N. S. Wales, 1900, vii p. 17.

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The map of Yalwal Gold-field accompanying this Report is fairly accurate with respect to the central portion. The junctions of the sandstone with the granitic rocks to the north-west and south-west of the map are, however, approximately correct only. This is due to the broken nature of the country, and the scrubby character of the vegetation.

I desire here to cordially thank Mr. A. F. Mixner, manager of the Homeward Bound Mine; Mr. V. Petherick, the former manager of this property; Mr. I. I. Chapple, manager of Mr. A. Hay's properties; Mr. C. Potts, B.A.; Mr. John Maclean, of Nowra; Mr. Durkin, manager of Grassy Gully Mine; Mr. A. Hielman; Mr. H. Martin; Mr. J. Sivewright; Mr. G. Davidson; and many others, who have most courteously volunteered both help and information.

The maps and sections, were prepared by Mr. O. Trickett, L.S., of the Geological Branch.

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History of the Development of Mining at Yalwal.

In 1852, Mr. A. Mackay, Commissioner of Crown Lands for the County of St. Vincent, communicated with Mr. J. R. Hardy, Commissioner of Crown Lands, concerning the geological and auriferous character of the Yalwal District.*

During various periods between 1860 and 1872, the Rev. W. B. Clarke, examined the district under consideration in some detail.†

In these earlier days the whole country stretching from the mouth of the Yalwal Creek to the head of the Yarramunmun (known as Sassafras), belonged to W. Elyard. Toorooroo, situate at the junction of the Danjera and Yarramunmun Creeks, was the head station; and close to this spot, early in 1870, the first real efforts at prospecting were undertaken.

The original prospectors were Messrs. J. Sivewright, J. Brakewell and S. Donovan. The site chosen for working the alluvial was along the Danjera, immediately above its confluence with the Yarramunmun. Here 350 feet of boxes for sluicing operations were set up. From this alluvial claim, J. Sivewright, with six men on wages, recovered 1½ to 2 ounces of gold per week.

The great flood of 1871 washed away all the sluicing apparatus, and caused suspension of operations for a time.

In the same year, and a little higher up the creek, J. Sivewright and E. Curtis discovered reef gold *in situ*. The spot is now known as "The Pinnacle" or No. 1 Claim. The stone was found on the summit of a bluff rising some 150 feet out of the creek.

Prospects were crushed in a sandstone mortar.

A parcel of 2 cwt. was sent to Mort's, in Pitt-street, with a result of 7 dwt. per ton from surface stone. This dismayed the prospectors for a while, but on Sivewright's return from Queensland in 1873, he essayed a second time the working of the Pinnacle.

From a small parcel of ore 30 oz. of gold were obtained. For four months' work the result was 140 oz. of gold.

The stone was carried down the bluff to the creek, and dollied there by means of crowbars working in nail cans. By preliminary roasting of the ore each man was enabled to crush 56 lb. weight per day. The gold was then amalgamated dry after passing the crushed material through very fine sieves. The prospects being still payable, one of Dr. Beer's one stamper spring machines was procured. This gave a strike equal to 2 cwt. One man with this machine could crush half a ton of stone per week. The returns were from 24 to 30 oz. per ton, extracted from hard clean quartz.

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* W. B. Clarke, Southern Gold-fields, pp. 39-40. Also Appendix I to this report. † *Ibid*, pp. 40-45. Also Appendix II.

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Shortly afterwards, a 3-head battery, constructed at Lutton's, supplanted Dr. Beer's machine. With the improved machinery, 3 to 4 tons of stone were crushed every week.

In 1871, alluvial gold was obtained in Sawpit Gully. The metal was coarse in character, but did not appear to occur in payable quantities.

E. Aldis and J. Caddle discovered gold in 1872 from surface prospects on the property now known as the Pioneer. The stone was treated at the creek below, but the gold was of too fine a nature for the crude methods of saving employed, and prospecting was discontinued on this claim for a period.

About the year 1874 Michael Harvey and another found gold on the present Homeward Bound Claim.

About the year 1875 J. MacArthur & Company erected a 5-head battery, driven by an engine of 8-horse power. It was an odd five of an original 30-head battery, procured for the Upper Shoalhaven River.

A 16-ton parcel was made up from the Homeward Bound Claim, and crushed at this battery. The result was 1 oz. 6 dwt. per ton.

J. Sivewright and Party hired this plant for their work, its crushing efficiency being 40–45 tons per week.

Gold in the stone (the Pinnacle) varied from 1–3½ oz. per ton. The Pinnacle owners used this plant for 12 months. The property was then taken up by a company of 24,000 £1 shares, with 12,000 paid up to £1.

The Homeward Bound Claim was then taken up by T. Thorburn and Party. In 1887 they bought a 10-head battery from J. MacArthur & Company, which had been originally used for public crushings, and fixed it on the site of the present cyanide plant. A shaft was sunk for 50 feet on a quartz vein, but later, finding that the gold was scattered in "stringers" throughout the country, the company excavated a large chamber in the vicinity of the quartz vein. More gold was found from surface crushings near the original workings. The surface was then broken through and the open cut system established. The country was worked north and south for gold.

As the success of the Homeward Bound Claim became assured, another trial was made on the adjoining Pioneer property.

A shaft was sunk on a small quartz "leader," and good returns were crushed from the same. Stoping was resorted to, and several crushings taken from both shaft and stope.

Prior to 1885, the original company (consisting of T. Thorburn, J. Maclean, and 30 others) had sunk the shaft 60 feet.

The claim next to the Pinnacle on the north, and known as the Eclipse or No. 2, was taken up by J. Maclean and Party about the year 1874.

A 10-head battery was erected in 1878. This was purchased from Dr. H. J. Tarrant. The second crushing gave a result of 7 oz. gold per ton from 761 tons of ore.

In 1881, £2,795 worth of gold was extracted from this claim.

In 1880, E. Curtis and E. Fletcher discovered gold in a claim north of the Eclipse property, and known as the Poor Man.

In February, 1881, a 15-head battery was procured for the Pinnacle Company from the Atlas Works. This company at the time mentioned was known as the Yalwal Quartz-mining Company.

The "Star" lease was taken up by Kennedy, Maclean and Party in 1883. The shareholders numbered eighteen. £2,000 were spent in driving tunnels without any return.

This property immediately adjoins the Homeward Bound lease to the south, and it was the prosperity of the latter which urged the lessees of the Star to take up and explore the claim.

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Accordingly three tunnels were put in as closely as possible to the southern boundary of the neighbouring property. The tunnels were driven vertically above each other in the rough hillside which composes the claim.

The lower tunnel was started in 1883 and completed in 1885. Its length is 450 feet and its direction easterly. This is near the level of the creek.

The upper tunnel was driven by Peter Matson in 1887, under the sandstone capping of the hill, and 350 feet above the level of the creek. The total length driven was 200 feet.

From this part of the claim 10 tons of stone were extracted in 1893, yielding an average of 7 dwts. of gold per ton.

A middle tunnel was also driven about 100 feet below the upper one between the years 1890–92. The total length driven was 350 feet. Prospects amounting to 10 and 12 dwt. per ton were obtained from this working.

Prior to 1885, the work on the Pioneer consisted of a shaft some 50 or 60 feet deep, and a few small surface workings.

Mr. J. Hanson, in 1890, bought the property for £15,000. Stone taken from various spots on the lease gave satisfactory results, individual crushings yielding returns as high as 3 oz. per ton. Three quarries, or open cuts, exist on this property. The two westerly ones represent earlier exploitings for gold. The eastern one, shown on the map as continuous with the Homeward Bound open cut, is of more recent date than the others.

A tunnel was driven nearly 900 feet into the hill in 1891. In 1901 the tunnel was carried a further 100 feet. The idea was to test the hill, and to connect the open cuts with the battery.

Another tunnel at a higher level was driven 400 feet to prove the property, and to connect the workings with the main pass.

A 40-head battery was erected by Mr. Hanson in 1891.

The property was then resold to a Nowra syndicate, having practically the same *personnel* as the original company. This was in 1892.

The approximate cost of erecting the mining plant and in developing the property was £27,000.

The Caledonian Claim was taken up in 1885, and amalgamated with the Star in 1887.

In that year, prospectors found an auriferous vein in the first-named property. A 5-head battery for public use was employed, a road being cut round the hillside to convey the ore to the battery. One hundred tons were crushed from the lease for a return of £500, the maximum yield being 6 oz. per ton.

The road just mentioned passed through what is now known as Underwood's Cut, splendid stone lying unnoticed on the roadside for four or five years.

The mine lay idle until 1892, in which year W. Underwood and R. Johnson took the mine on tribute. Opening up a small quartz vein showing in the roadside at Underwood's Cut, they crushed, at the first trial, stone varying from 23 to 30 oz. of gold per ton. From this vein, varying from 3 to 9 inches in width, they crushed £3,500 worth of gold in three months.

One parcel of 34 cwt. yielded 750 oz. of gold. This rich stone was, from all accounts, very unpromising in appearance; only on being crushed or scratched did it reveal its true nature. The tributers, apparently, then lost the vein against a "floor."

Fletcher Brothers then took the property on lease from the original tributers. Following the "floor" up, they again came on the vein, which proved richer than before.

Fletcher Brothers won £6,500 worth of gold as the result of their tribute.

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These latter then closed in with an offer of £950 from the original company, who, in a short space of time, extracted gold to the value of £6,900.

Other veins, running parallel to the direction of Underwood's Cut and known as Ison's and Sandeman's Cuts, were worked also with success, the stone varying from 2 to 6 oz. of gold per ton.

In 1886, the Eclipse Company, having excavated a system of large chambers from an extensive lode formation, connected the same with their battery by means of a long and sinuous tunnel.

From 1882 to 1889 the Homeward Bound Company crushed with a 10-head battery.

In 1885, £5,132, and in 1887, £6,105 worth of gold was won by the company.

After 1889, the property was sold to the Homeward Bound Gold-mining Company, who erected twenty head of stampers (exclusive of the original 10-head battery).

In 1891, another twenty head of stampers was added, and two years after the original 10-head battery was incorporated with the 40-head, to form a 50-head battery.

From June, 1893, to December, 1896, the mine was hampered considerably, sometimes closed altogether, owing to litigation.

This threw the miners out of employment, and an alluvial prospect being found by Middleton and Prince, in a shaft 15 feet deep, in Sawpit Gully, a small rush took place in 1893.

Thirty men were soon at work, the gully being rushed, although the ground was leased. £2,500 worth of gold was extracted in eight months. Nuggets varying in weight from 15 dwts. to 2 ozs. were found.

In 1894, J. Sivewright and T. Mason attempted to sink through a vesicular dolerite at Grassy Gully (five miles north of Yalwal) for alluvial gold.

The following year, R. Ison and Charles Moffatt discovered payable gold at the same locality (Grassy Gully).

This was in close proximity to the sandstone cap which forms the ridge between the Shoalhaven River and Yalwal Creek. The auriferous belt was found to extend in a north and south direction through a rhyolite flow, and the country was rapidly taken up over a narrow area exceeding a mile in length.

In 1896, a great number of the minor properties belonging to the Yalwal area were worked with varying success.

In this year 113 tons of stone were crushed, for a return of 188½ ozs. of gold, from "The Golden Quarry" (G.L. 27.28).

In the early part of February, 1898, a cyanide plant was erected by the Pioneer Company.

During the same month, the Homeward Bound Claim was placed under new management. Mr. Petherick came into charge, and, in view of the low class of the ore, he decided to erect an experimental cyanide plant.

Mr. A. F. Mixner had charge of the cyanide plant. It worked so well that a much larger plant was erected, which ultimately became the mainstay of the mine.

In November, 1900, Mr. Mixner was appointed general manager.

Moffatt, one of the discoverers of Grassy Gully gold, took up a lease in this locality in 1895, and sold, shortly afterwards, to the Anglo-Australian Company. The lease was forfeited in June, 1898, and taken up by Messrs. Hanson and Barron, by whom it was worked for nine months.

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It was then sold to Mr. W. H. E. Lovely and Party, and worked for six months.

In January, 1900, it was formed into the Grassy Gully Gold-mining Company, with P. Durkin as manager.

The mine had been sunk to 185 feet in June, 1900.

A 10-head battery and a Wilfley vanner were erected in September, 1900.

Summary.

1852. Report on Yalwal, by Mr. A. Mackay. Reports by Rev. W. B. Clarke, F.R.S.
1870. Prospecting for alluvial by J. Sivewright and Party.
1871. Abandonment of sluicing operations. Alluvial found in Sawpit Gully. Discovery of gold *in situ* (Pinnacle).
1872. Gold discovery in Pioneer Claim.
1873. Pinnacle worked a second time.
1874. Gold discovered in Homeward Bound Claim. Eclipse Claim taken up (?).
1875. Erection of 5-head battery for public crushing purposes.
1878. Ten-head battery erected for Eclipse Claim.
1880. "Poor Man" discovered.
1881. Fifteen-head battery procured for Pinnacle.
1883. "Star" lease taken up.
1885. "Caledonian" lease pegged out.
1887. Homeward Bound Company purchased 10-head battery.
1889. Additional 20-head of stampers erected for Homeward Bound Company.
1890. Mr. J. Hanson purchased Pioneer property for £15,000. Forty-head battery erected for Pioneer property.
1891. Pioneer Lower Tunnel driven 850 feet.
1892. Additional 20-head battery erected for Homeward Bound Company. The old 10-head included, bringing total up to 50-head. W. Underwood and R. Johnson crushed £3,000 worth of gold in three months from Caledonian Claim. Pioneer property rebought by original shareholders.
1893. £2,500 worth of alluvial gold won from Sawpit Gully.
1894. T. Mason and J. Sivewright attempted to sink through dolerite for alluvial in Grassy Gully.
1895. C. Moffatt and R. Ison discovered gold at Grassy Gully. "Grassy Gully Mine" started. Pioneer and Caledonian properties yielded £18,565 worth of gold. 4 tons crushed from Caledonian for 1,664 oz. of gold.
1896. Numerous minor properties worked.
1898. Cyanide plant erected for Pioneer Claim. Experimental cyanide plant erected for Homeward Bound Claim.
1900. Present Homeward Bound cyanide plant erected (March). Ten-head battery and Wilfley vanner erected at Grassy Gully.

Physical Geography.

Yalwal, by road, is about eighteen miles west of Nowra. It is approached from the latter by crossing a couple of ridges, and is situate at the base of a gorge, through which the Danjera Creek flows in its passage to the Shoalhaven River.

For a distance of seven miles out of Nowra, the road makes a gradual ascent for about 600 feet. Saltwater Creek is then crossed. Thence to the 16-mile peg, the road follows a narrow ridge, at which point a descent is made of 900 feet to the junction of the Danjera and Yarramunmun Creeks.

Drainage System.—The Shoalhaven River has a northerly course from Braidwood to Bungonia. A little below the latter place, however, it alters its direction sharply to the east. Sweeping clean through the mountainous belt between Bungonia and the coast, it persists in its new course until it reaches the sea, eighty miles distant. In this easterly direction it drains the whole of the Yalwal District, and takes in also the waters of the Kangaroo River.

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The country is very rugged and broken, especially to the west of Yalwal. The district represents a thoroughly dissected plateau with ridges or "razorbacks" marking the extensive denudation to which the old upland has been subjected, and, at the same time, separating the various creeks, which feed the Shoalhaven, from each other.

From an eminence immediately behind the village of Yalwal, and 1,250 feet above the Danjera Creek, the leading features in the topography can easily be made out.

To the north and west the Shoalhaven River has eroded an old sandstone plateau to a marvellous extent. From the spot where it gathers in the waters of the Kangaroo River (and also far above this point) to its junction with the Yalwal Creek, bold escarpments, 2,000 feet and more in height, with cliffs 1,000 feet high in places, mark the course of the cañon-like valley of the main stream.

A little below its junction with the Yalwal Creek, the river spreads itself over the flatter country caused by the retreat of the hills from the stream. On the east bank, the huge pile known as the Cambewarra Mountain (a portion of the coast range), 2,000 feet in height, divides the waters of the main stream from its large tributary, the Kangaroo River. This highland supports luxuriant growths of grass, which constitute one of the sources of wealth of the district. Thence towards the sea the mountains dwindle in height, and with the exception of Coolongatta, a rounded eminence, 1,000 feet high, they become less and less separable from the gentle undulations of the surrounding country.

The creeks in the immediate neighbourhood of Yalwal are the Danjera (Plate II), the Right Arm or Bundundah, the Ettrema, and the Yarramunmun. These have approximately parallel courses for considerable distances, finally joining the Yalwal near its confluence with the main stream.

The sandstone cap constituting the former plateau at one time extended in unbroken continuity from the present coast line through Yalwal and across the Shoalhaven River. This has since been trenched or dissected so thoroughly in the vicinity of Yalwal by the creeks just enumerated that their courses are marked by gorges varying from 1,000 to 1,500 feet in depth, the summits of their various watersheds being represented merely by lines of cliffs in many places not more than a chain in width.

The cap comprises two series of hard sandstones, with soft intercalated shales. These harder beds divide the district into two "platforms" or "terraces." The upper some 200 feet thick and from 1,200 to 1,400 feet above the creeks, forms precipices over which the pioneers of the district found it difficult to force a way. Also a lower platform 500 feet below the upper one, and some 150 feet in thickness. This also faces the valleys in precipitous manner.

The upper series is broken here and there by lower gaps or passes allowing ingress and egress to and from the valleys.

The hard strata underlying the sandstone cap are exposed at a general height of 500 feet above the creeks. These, unlike the sandstone (which forms "terraces"), weather out into long hard spurs, which advance to the creeks from the cliffs above, after the manner of great buttresses.

These platforms or "terraces" are to be expected in greatly denuded horizontal strata, where the beds are of varying hardness. A still later phase of denudation is the "mesa" stage, when creeks have so intersected a plateau as to leave isolated flat-topped hills with precipitous sides. Several examples of these occur in the vicinity of Yalwal. They are about 1,000 feet in height, have high cliffs surmounting very steep slopes, and possess quite flat tops, a few acres only in extent.

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GENERAL VIEW OF DANJERA CREEK FROM THE PINNACLE CLAIM. PIONEER AND HOMEWARD BOUND BATTERIES IN THE MIDDLE GROUND.

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The appearance of the Devonian rocks conforms also to the generally observed order of phenomena in the weathering of strata nearly vertical, containing beds of varying hardness, *i.e.*, rough spurs with dyke-like formations (representing the harder layers), running parallel to the strike.

The valleys widen in and out most capriciously. The trend, however, of the minor streams is nearly north and south.

Five miles above Yalwal, along the Danjera Creek, bluffs occur nearly 1,000 feet in height, composed of red granite and rhyolites.

Meteorology.—Yalwal, although eighteen miles only from Nowra, experiences intense heat in summer. This is due to its being cut off from sea influences by a mountain ridge, 1,100 feet high, rising immediately to the east of the village and trending so as to intercept any sea breeze; to the narrowness of the gorge itself in which the village is situated; and to the fact of its being less than 200 feet above sea level. On exceptional days the shade temperature reaches 115° Fahrenheit.

The rainfall varies from 40 to 50 inches per annum.

Vegetation.—The granite areas contain great escarpments supporting a very meagre and stunted vegetation.

The sandstone below the upper line of cliffs supports dense growths from six to ten feet high, through which it is difficult to force one's way. The lower gullies, enclosed by the spurs of Devonian strata, are full of myrtle and allied growths, while the basic igneous rocks may at times be traced by the luxuriant crops of grass they support when cleared of timber.

General Geology.

The surface of the Yalwal District being much broken, very little difficulty is experienced in ascertaining the various sedimentary and igneous rock junctions. They are, however, obscured in many places owing to the great amount of talus derived from the Permo-Carboniferous sandstone, and the thick scrub-growths that fill the gullies.

The geological formations of this locality are as follows:—

1. Recent and Pleistocene—Alluvium and river terraces.
2. Permo-Carboniferous—Lavas and tuffs, upper marine sandstones.
3. Carboniferous—Granites and quartz-felspar porphyries.
4. Devonian—Dolerite sills, rhyolite lavas, dolerite lavas, slates, quartzites, conglomerates, schists, and shales.

1. *Recent and Pleistocene.*—To this date belongs the period of deposition of alluvium in the various creeks about Yalwal. The Shoalhaven is said to possess river "terraces" or marks of former river levels. These may be referred to this period also.

2. *Permo-Carboniferous.*—The formations of this period consist of a huge covering of sandstones, grits, and mudstones, which formerly extended across the whole of the district. The older underlying formations have been exposed by the erosion of this Permo-Carboniferous crust.

To understand the geological position of this sandstone cap, a brief *résumé* of conditions obtaining in New South Wales during Permo-Carboniferous times is inserted here:—

The Permo-Carboniferous period was the great coal making epoch of the southern hemisphere, and is further remarkable by reason of great alternating periods of heat and cold (glacial periods) which occurred shortly after the Carboniferous period.

In New South Wales, the period is divided into several great divisions.

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The oldest beds comprise *The Lower Marine Series*, consisting of various sedimentary rocks containing marine fossils. This series is 4,770 feet in total thickness, and contains abundant evidence of glacial action in its lower beds.

The *Greta Coal Measures* were then laid down. The equivalent of these in the South Coast District is the *Clyde Seam*.

To this succeeded the *Upper Marine Beds*, a mass of sedimentary rocks 5,000 feet in maximum thickness. Especially well are these beds developed in the Maitland District. Great periods of cold occurred also during the deposition of these beds.

It is to this latter series that the Yalwal sandstones belong. They lie directly on the older Carboniferous granite and Devonian inliers with no intervening coal seam (Clyde); since the granite hills represented high land during the deposition of the Greta or Clyde coal.

Subsequently the great *Maitland* and *Newcastle Coal Measures*, with a total thickness of 3,900 feet, were deposited. Both of these are supposed to have coalesced to the south to form the *Bulli Seam*. This also is absent from Yalwal. If present it would form a cap to the sandstone above the Yalwal Trig. Station.

After the deposition of the coal measures a great period of volcanicity supervened. The lavas and tuffs of Cambewarra and Kiama are expressions of this volcanic activity.

3. *Carboniferous.*—To this period the granites and quartz-felspar porphyries of the district may be assigned.

4. *The Devonian.*—The formations belonging to this period consist of rhyolite and basic lavas, basic sills, and various metamorphosed and folded strata.

The Permo-Carboniferous sandstone, although subjected to extensive denudation, still occupies by far a greater extent of the surface rocks than those of Carboniferous and Devonian age. Only at the bases of the ravines can the latter be examined, with the exception of a few granite and rhyolite hills lying some six miles to the south and south-west of Yalwal. These were the more prominent features of the landscape in early Permo-Carboniferous times, just prior to their sinking below the sea in the Upper Marine period. Even these higher points are, however, but partially exposed.

It will thus be seen that our knowledge of the formations older than the Upper Marine are confined to exposures found in the lower parts of the various gorges of the district.

Yarramunmun Creek.—In following this watercourse above its junction with the Danjera, a narrow belt of contorted strata is found underlying the sandstone as far as Dean's Flat. A valley existed here in the Pre-Upper Marine times, and sandstone alone is found filling the basin.

The Danjera Creek at Yalwal exposes numerous belts of basic igneous rocks, whose strike conforms to that of the contorted strata they are associated with. Two miles above the village these open out into steep grassy hills abutting on to the creek, while immediately alongside of these rise rough, broken hills of quartz-felspar, porphyry, and granite.

Four miles above the village the granite advances across the creek, and occupies most of the valley slopes.

A couple of miles higher up still, great precipitous faces of rhyolite succeed to the rounded masses of the coarser granite. In places these rhyolite masses rise nearly 1,000 feet above the creek, and present the appearance of the rougher granite gullies of New England.

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The formations exposed by the Right Arm or Bundundah Creek are repetitions, mainly, of those found in the Danjera Creek. Amygdaloidal lavas are very plentiful. Quartz-felspar porphyries are in evidence toward the head of the creek. The lower five miles of the creek sides consist of a fine grained and very siliceous granitic type of rock.

The Yalwal Creek slopes from their start as far down as Mackenzie's Station, consist almost solely of granite and porphyries. The land at the station itself is a series of steep, well-grassed downs, consisting of vesicular basic rocks, with long lines of acid rocks either alternating with or intrusive into the basic rocks.

Thence to the Shoalhaven the underlying rocks occur as bold escarpments of contorted strata and felsite lavas. Especially well are these seen near the junction of the Ettrema and Yalwal Creeks. Cliffs several hundreds of feet in height expose sections of strata bent into almost perfect folds, standing out in sharp contrast with the overlying horizontally bedded sandstone.

Near the Shoalhaven the sandstone encroaches on the Yalwal Creek, and occupies even the lowest part of the gorge.

The older formations between Yalwal Creek and Grassy Gully are almost entirely hidden beneath the sandstone cap.

At Grassy Gully itself, the older rocks are exposed in part and rhyolite flows associated with basic amygdaloidal rocks occupy the gold mining area.

It will thus be seen that (*vide* map) a very large area of the underlying rocks consist of rhyolites, quartz-felspar porphyries and granites. They may be considered as extending from the village west and south-west right under the sandstone across the Right Arm Creek, and northwards for miles along the Yalwal Creek.

A considerable area is occupied also by basic igneous rocks.

These basic rocks, intrusive or as contemporaneous flows, consist of amygdaloidal and compact ophitic dolerites and basalts in an advanced stage of decomposition.

The order of succession appears to be as follows:—First, a series of Devonian mudstones, sandstones, and allied rocks were laid down.

Intermittent periods of intense volcanicity occurred at this period, during which immense rhyolite and basic flows were poured forth from various local centres.

The higher members of the Devonian series consist of soft shales, grits, and soft and hard brown tuffaceous material containing numerous *Lepidodendron* remains. With these are associated several sheets of very vesicular dolerite, numerous dolerite sills, and smaller rhyolite flows.

The dolerite sills may be contemporaneous with some of the interbedded sheets, or they may be of later origin.

At a much later date, probably in Carboniferous times, quartz-felspar porphyries (typically as vertical bosses or tongues) and red granites of most pronounced acid affinities made their appearance.

To this date, also, probably belongs the age of the auriferous deposits.

The whole surface then suffered long-continued denudation, causing the aforetime fairly deeply-seated granite masses to stand out boldly above the general surface.

The sinking of the district was accompanied by a deposit of Upper Marine sandstone.

Subsequently the slumbering volcanic forces again came into play, and the basic lavas and tuffs of Sassafras, Cambewarra, and Kiama resulted.

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The reasons for assuming these ages and the order of succession is as follows:—

The Age of the oldest Strata.—These are assigned to the Devonian, both on account of their lithological characters and their mode of occurrence.

The Rev. W. B. Clarke* placed these sediments in two divisions—

(1) An upper series containing *Lepidodendron* and *Sigillaria*. These he included as Carboniferous.

(2) A lower series composed of quartzites, slates, &c., and comprising the gold-bearing rocks. These he placed in the Silurian.

Lepidodendra obtained from Mr. Clarke's upper series have been described as follows by Mr. W. S. Dun, Palæontologist to the Survey:—"A most interesting, small-patterned *Lepidodendron*. The leaf bases vary in size from 3mm. x 2·25mm. to 4mm. x 3mm. Several specimens, however, show a more elongated form—7mm. x 4mm. The leaf cushion is well raised, about one-third along axis from the apex of the leaf-base. The print of the vascular bundle is well marked. No traces of parichnos or ligule are preserved. There appears to be no doubt that this species is new. The smaller leaf bases have much the appearance of some forms described as *Ulodendron* (without the large rounded scars). There is an apparent resemblance to forms of *L. Sternbergi* and *L. Heeri*, Nathorst from Spitzbergen. A description and figures will be published in the forthcoming "Records of the Geological Survey."

The *Sigillaria* mentioned by the Rev. W. B. Clarke has not been discovered since.

In the Eclipse and Pinnacle workings well-preserved *Lepidodendra* occur, and identical with those found in the upper beds.

The broad belts of conglomerate traversing the Pinnacle, Eclipse, Golden Crown, Usher, and Caledonian Claims are also probably closely related with the less altered conglomerates of the Jinkbilly Creek.

The evidence points, therefore, to one formation rather than to two distinct periods of deposition. The apparent break in the geological continuity is caused by altered topographical conditions occasioned by the sudden disappearance of the amygdaloids, whose presence causes steep grassy downs, and whose absence allows of rugged gullies in the slates and quartzites, and a fold in the country which has given the idea of a basin (containing *Lepidodendron* remains) in the midst of older formations.

The old rhyolites and dolerites around Grassy Gully appear to be contemporaneous with the associated Devonian strata.

Two great sheets of rhyolite lava are separated by a 2-chain wide band of very vesicular dolerite.

Between the dolerite and the upper sheet a thin selvage of tuffaceous mudstone and slate occurs.

The rhyolites to the south of Yalwal represent yet other enormous acid flows, or the continuation of those occurring at Grassy Gully and cut off by the granites.

Here, also, two rhyolite sheets are separated by a large dolerite sheet. Between the two a belt of basic tuffs occurs.

The banded nature and characteristic contortion flow-structure of the rhyolites, the presence of acid tuffs, the very marked vesicular character of the dolerites, the presence of basic tuffs, the intercalation of mudstones, shales, and allied rocks with the igneous rocks, and the coincidence of strike as regards both igneous and sedimentary rocks, point to great alternating submarine outbursts of acid and basic lavas in Devonian times.

* Southern Gold-fields, pp. 41, 240; also Appendix 2 to this Report.

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"THE BUCK REEF." AN ALTERED CONGLOMERATE BELT NEAR THE PINNACLE CLAIM.

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THE GAP SHOWING BLUFFS OF UPPER MARINE SANDSTONE.

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The sills (?) are placed as younger members of the series, on account of their apparent origin :—

(*a*) They are unaccompanied with tuffs.
(*b*) They transgress planes of bedding in places.

The granites and quartz-felspar porphyries send out long red aplitic dykes into the surrounding strata, the rhyolites, the basic lavas, and sills alike.

Both the granites and porphyries possibly represent different phases of consolidation of a plutonic mass, and thus may be of the same age.

In this limited area we have then :—

(*a*) Alternating basic and acid lavas of Devonian age.
(*b*) Granites and microgranites of Carboniferous age.
(*c*) Basic lavas of the Permo-Carboniferous.

The alternation of acid and basic lavas in Devonian times points, possibly, to a remarkable differentiation of a common magma. What that magma consisted of is not yet evident, as no plutonic "boss" has been discovered in the district which could serve as a feeder to the various lavas of the locality.

B.—Sedimentary Rocks.

(*a*) *Recent or Pleistocene.*—As mentioned before, to this period belong the alluvial of the creeks and the river terraces (?) of the Shoalhaven.

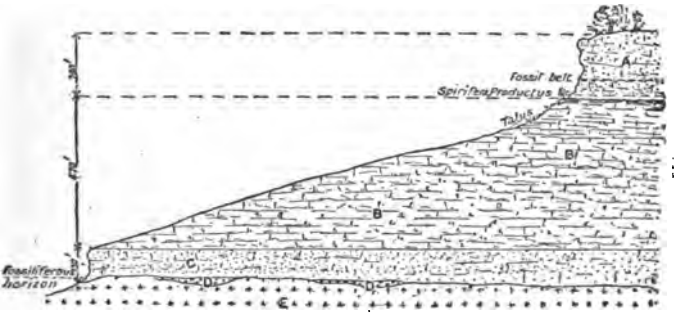
(*b*) *Permo-Carboniferous.*—This is represented by a thick capping of coarse and fine sandstones, mudstones, and shales of Upper Marine age.

The maximum thickness of the beds, occurring some two miles south-east of Yalwal, is 1,000 feet, and the general thickness varies from 600 to 800 feet.

The strata fall naturally into three divisions (see sketch) :—

(1) Lower.
(2) Middle.
(3) Upper.

Section of Sandstone Cap near Yalwal.



A. Upper hard belt of sandstone.
B. Middle belt of soft shales, sandstones, &c. ; almost barren of fossils.
C. Lower hard belt of sandstone.
D. Conglomerate.
E. Granite.

(*a*) *Lower Beds.*—These consist of hard belts of sandstone varying from 25 to 200 feet in thickness.

The basal beds lie upon patches of conglomerate, and consist for the greater part of coarse and hard sandstones, brownish-black, red, yellow, and white in colour. Intercalated with these are soft white sandstones and mudstones containing numerous plant impressions.

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The cementing material consists generally of red and yellow oxides of iron, with traces of manganese oxide.

Numerous fossil remains occur in the lowest of the beds.

The conglomerates, which are very patchy, and appear to occupy local hollows once existing in the underlying formations, are composed of granite and quartz pebbles.

(*b*) ***Middle Beds.***—These comprise a mass of soft sandstones, mudstones, and carbonaceous shales, weathering into gentle land slopes.

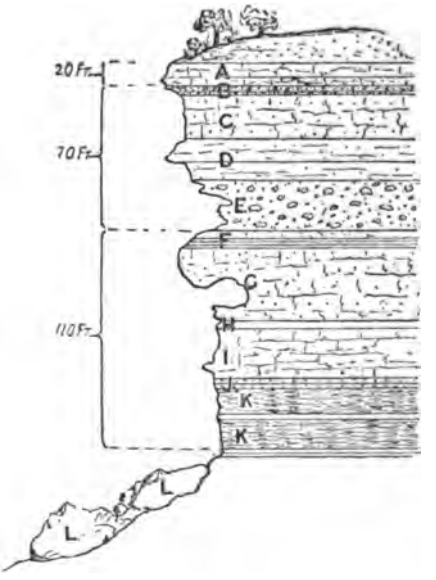
The members of this series are frequently full of whitish micaceous material, and are almost barren of fossil remains.

(*c*) *Upper Beds.*—These consist of very coarse sandstones lying upon fine shales, and passing above into alternating grits and conglomerates.

The maximum thickness is 200 feet in the immediate vicinity of Yalwal. The lower shales are frequently black by reason of much carbonaceous matter present.

One of the shale beds is eighteen inches in thickness, and is composed of masses of *Productus* and *Spirifers* remains held loosely together by soft cement.

SKETCH SECTION OF UPPER PORTION OF UPPER MARINE SANDSTONE CLIFFS, AT YALWAL.
Top of cliff 1,050 feet above Danjera Creek.



White sandstone.....
Red and Yellow sandstone.....
Black carbonaceous ....
Sandstones and Shales.....

Reference.

A. Coarse unfossiliferous sandstone.
B. Thin beds of conglomerate. Casts of *Spirifera.*
C. Coarse sandstone.
D. Red sandstone with *Spirifera.*
E. Conglomerate, consisting of large quartzite pebbles and granite slate, quartz, &c.
F. Sandstone filled with *Productus* and *Spirifera.*
G. Coarse sandstone with alum deposits.
H. Fossil horizon.
I. Soft black sandstones.
J. 16 inch band, thick with *Productus*, &c.
K. Carbonaceous shales.
L. Talus blocks.

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The alternating fossil shales and coarse barren sandstones indicate rapid deposition with periods of more settled conditions when fossils flourished to such an extent as to form an integral part of the strata.

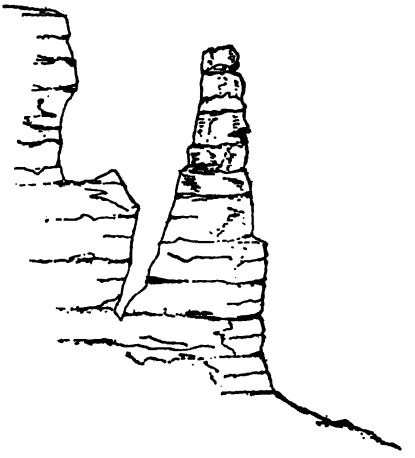
The conglomerates and grits consist of well rounded pebbles of rhyolites, granites, porphyries, and quartzites, and express the amount of degradation that the older strata were subjected to.

On superficial examination, the whole series presents lithological features analagous to those seen in the Hawkesbury sandstone of Sydney and its environments.

The Hawkesbury sandstone indeed forms the summits of the Cambewarra hills, just across the Shoalhaven.

Huge outlines of this upper series occur frequently. One represented below, and named the Chimney Stack, is 130 feet high, and but three yards in breadth at the summit.

"The Chimney Stack."



The fossils obtained from these sandstones have been named as follows, by Mr. W. S. Dun, Palæontologist to the survey :—

I. Lower Series.

Chænomya.
Platyschisma oculum. *J. de C. Sby.*
Spirifera. Sp. indeterminate.
„ tasmaniensis.
Martiniopsis subradiata. (Young).
Dielasma sp. indeterminate.
Mourlonia strzeleckiana. *Morris* (?).
Goniatites (Agathicras) micromphalum. (*Morris.*)
Martiniopsis oviformis. *McCoy.*
Aviculopecten cf. subquinquelineatus. *McCoy.*

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II. Upper Series.

Martiniopsis oviformis. *McCoy.*
Productus Crachythærus. *G. Sby.* (very abundant).
Spirifera tasmaniensis. *G. Sby.* (Young).
Dielasma inversa. De Kon. Sp.
Spirifer duodecimcostata. *McCoy.*
,, convolutus. De Kon. =S. vespertilio. *G. Sby.*
Protoretepora ampla, *var.* Woodsi. *Eth. fil.*
Pachydomus pusillus. *McCoy.*
Spirifera, very indistinct, may be S. duodecimcostata. *McCoy.*
(This occurred at the summit of the cliffs near "The Gap.")

At Grassy Gully the basal beds contained :—

Platyschisma oculum. *J. de C. Sby.*
Pleurophorus gregarius. *Eth. fil.*
Spirifera duodecimcostata. *McCoy.*

(3.) *Devonian.*

This formation underlies the whole of the cap of Upper Marine sandstone.

The general trend of these older rocks is approximately that of the main divide of the Colony, viz., north and south. Small variations from this meridional direction occur, causing the strike to vary between N.N.E. and S.S.W., N. 10° W. and S. 10° E.

The dips, however, are exceedingly variable, the whole district having been thrown into a series of folds.

As will be seen on the appended map of Yalwal, there is evidence of a syncline in the centre of the field.

Lepidodendron beds, grits, and contemporaneous lavas occupy the upper part of this syncline.

The conglomerates found in the Jinkbilly Creek, which have a decided dip to the W.N.W. at 45°, are very possibly represented at the opposite side of the syncline by what is known as the Buck Reef, possessing a variable dip, but almost invariably in an easterly direction.

Conglomerates similar to the Jinkbilly variety occur some seven or eight miles above Yalwal along the Danjera.

Evidence of sharp folding occurs near the mouth of the Ettrema Creek. Originally, perfect arches stretched across the whole width of the creek at this spot. These have been partially removed by atmospheric agencies.

Of the rocks composing this Devonian series, highly siliceous varieties, consisting almost solely of quartz grains, are the most common. Generally they are finely laminated, but at times occurring in beds from twelve to eighteen inches in thickness.

With these are associated curly and siliceous slates, mudstones, spotted slates, and quartzites.

Higher up in the series are conglomerates in various stages of alteration. The pebbles are well rounded, and consist, for the most part, of fine-grained quartzites and claystones.

Intercalated with them are mudstones, shales, and claystones.

These pass upwards into felsite and basic lavas with tuffs, grits, sandstones, and fossil shales.

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Eruptive Rocks.

(*a*) Rhyolite and dolerite lavas.

(1.) Field relations.—These lavas are so closely associated that they are here considered together, in so far as their field relations are concerned.

They persist in a N.N.E. and S.S.W. direction, over a distance exceeding twelve miles. What their further extension north and south may be, I am unable to say.

To the N.E. of Grassy Gully, on both banks of the Shoalhaven River, the rhyolites abut on the stream in precipitous manner.

Thence southwards, through Grassy Gully, the basic and acid lavas may be traced to the Upper Marine sandstone.

Reappearing at Yalwal Creek, the rhyolite is subordinate in amount to the dolerite, occurring only in small patches.

Here, however, the basic lavas make a great display, occupying almost the whole of Mackenzie's Station. These, however, appear to lie above the main rhyolite sheet.

The line of continuity of the lavas has also here been broken by the granitic intrusion.

Five or six miles above Yalwal, the associated rhyolites and dolerites appear to the south of the granitic masses, and then stretch for miles along the Upper Danjera, the rhyolites showing out beneath the Upper Marine sandstone as huge inaccessible cliffs, and the dolerites flanking them as steep wooded slopes.

The largest basic sheet is eight to ten chains in width, and may be traced for miles along the Danjera.

Beneath this again, in the bed of the creek, a second rhyolite outcrop occurs.

The acid lavas are pierced by the red granite in a remarkable manner, the intruding granite forming, throughout the rhyolite mass, an anastomosing system of lenticular veins and threads. The coarser rock partakes more of the nature of a huge apophysis than a boss, and roughly approximates to the strike of the rhyolite, piercing it in the manner above described for a distance exceeding two miles.

In Portion 1, Parish Yalwal, a small contemporaneous rhyolite occurs. It is of very limited extent, being some six chains in width and about 500 yards in length. It appears to have been intruded by one of the dolerite sills of the locality, and occurs among a great number of basic flows.

Contemporaneously with the more important *Lepidodendron* beds, several acid and basic lava flows occurred, accompanied by tuffs.

In Fletcher's paddocks, to the east of the Jinkbilly Creek, a similar condition of things obtains.

The great development of the dolerite sheets may be inferred from a glance at the map.

In some of the patches marked on the map as "dolerite lavas and tuffs, with associated sedimentary rocks," as many as a dozen basic sheets occur in less than a quarter of a mile traverse across the strike of these beds. These alternate with the *Lepidodendron* shales, felsite tuffs, tuffaceous mudstones, &c.

(2.) *Structures observable in the Field.*

(*a*) Rhyolites.

These possess conspicuous flow-structure. Well developed complicated flow-contortion markings are also common, imparting to the rocks the appearance of intensely folded laminated strata.

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At Grassy Gully, the surfaces of the flow structure are persistently straight for considerable distances. In the process of weathering, these have become divisional planes, and the similarity to tilted laminated rocks is very pronounced.

Here, also, a certain amount of crushing is observable locally, the fragments being cemented by silica. These rhyolite breccias possibly bear some connection with the movements which caused the Grassy Gully reefs.

Along the Upper Danjera, porphyritic felspars are plentiful. Around these the flow structure is well shown, the felspars giving to the rhyolite an appearance similar to the "eye" structures of certain rocks.

The bands generally weather out in alternate black and white tints. Many of the black bands are not continuous in the lavas south of Yalwal as they are at Grassy Gully, but appear in the form of flattened spindles and cylinders with drawn-out ends.

The rock also develops locally as a black flinty-looking mass, filled with white inclusions.

A most interesting feature is the occurrence of large spherulites, varying in size from a pin's head to subspherical and ellipsoidal bodies two inches in diameter. The flow structure passes uninterruptedly through them. Concentric structure is plainly visible in some of the individual spherulites.

These interesting structures are described in rhyolites from other localities.

From Pambula nodular felsites have been described.*

Banded rhyolites occur at Bulladelah, containing spherulites over an inch in diameter. These belong to the Permo-Carboniferous.†

The spherulitic rhyolites of Yellowstone Park,** The Channel Islands,†† Hungary,‡ and other localities,‡‡ have been described in detail.

For the discrimination of structures, these rhyolites should be studied in the creek exposures. Here the selective action of the water has exposed their peculiarities. In the mass they are obscured, owing to the apparent homogeneity of the rock in fresh fractures, and its characteristically decomposed nature.

(*b*) *Dolerites.*—These consist of a series of dark-greenish black rocks, of high specific gravity, exhibiting most decided vesicular structure. The vesicles are frequently filled with products of decomposition, causing the rocks to become amygdaloids. The amygdules consist of soft chloritic products, quartz, calcite, and epidote. Calcite and chlorite are the most common of these secondary minerals.

The rocks have suffered great decomposition, long strings of epidote and serpentine crossing the rock frequently.

Very vesicular types occur to the immediate south-east of the cemetery, the east side of Sawpit Gully, and in front of the Public School.

Copper, associated with abundant zinc blende, iron, and arsenical pyrites, has been found in one of the dolerite flows. The occurrence is three miles above the village.

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* J. E. Carne. Ann. Rept. Dept. Mines N.S. Wales for 1896, pp. 111, 112.

† E. F. Pittman, Min. Res. N.S. Wales, 1901, p. 416.

** Iddings, vii Ann. Rept. U.S. Geol. Survey, 1888, 249-295.

†† J. Parkinson, Q.J.G.S., 1898, liv, 101-118.

‡ Cole and Butler, Q.J.G.S. 1892, xlviii, pp. 488-445 and references.

‡‡ Harker, Petrology for Students, 2nd Ed., 1897, p. 189.

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(2.) *Intrusive dolerites.*

These possess great similarity to the contemporaneous basic lavas. They are generally fine-grained, greenish, and very compact rocks, devoid of vesicular structure.

It is probable that they are closely related in age to the higher members of the Devonian contemporaneous flows. They appear to transgress the bedding planes of the associated strata.

3. *Granites and microgranites (acid porphyries).*

The area occupied by the acid eruptives, as also their probable age, has been referred to in the notes on the general geology.

The occurrences are mostly of the nature of vertical bosses and huge tongues of quartz felspar porphyry. The main central mass may, however, be of the nature of a boss which has tilted the surrounding strata.

The rocks consist of red granites, quartz and felspar porphyries (microgranites), and aplite veins.

The granite is of medium coarseness, and is composed, essentially, of quartz and red felspar. Ferro-magnesian constituents are conspicuous by their absence. When present, they are of the nature of biotite or chlorite.

The porphyries consist of crystalline quartz and felspar in a pink granular base of the same minerals, the crystals being decidedly porphyritic towards the base. The quartz is of the smoky variety.

The unaltered quartzes, with their perfect contours set in a pink matrix, the latter only just discernible as granular in hand specimens, present a very fine appearance.

Miarolitic structure is well shown in a few varieties, the druses being very plentiful, the quartz and felspar being perfectly crystallised in the cavities.

The granitic and micro-granitic structures appear to shade off into each other by every gradation. As a rule, however, the granitic structure is confined to the more central portions of the larger masses.

Five or six miles above Yalwal the rock is typically a fine-grained granite, red in colour and miarolitic in character.

The porphyries of the Danjera Creek frequently weather out into pinnacle forms. As they become more granitic in character, typical granite weathering obtains, the sharp pinnacles giving place to dome-shaped hills.

About three miles above the village the rock is darker in colour, and is split up into huge slabs or tables by a uniform system of jointings possessing a south-east dip at 30°.

In Crawford, Johnson, and Hamilton Gullies, opposite the Homeward Bound battery, the rock approximates more to the quartz-felspar porphyries than the granites. The miarolitic structure is well marked.

The rock in the Yalwal Creek is also partly plutonic, and partly hypabyssal in habit.

Both varieties contain crystals of quartz; are almost devoid of ferro-magnesian constituents; and are crossed by a series of narrow aplite veins, probably representing segregation into cracks before final consolidation had set in.

It is here, along the road to Grassy Gully, that the finest examples of the porphyries occur.

In the great mass occupying the whole of the lower four or five miles of the Bundundah (Right Arm) Creek, the rock posseses the same high acid percentage as the Danjera and Yalwal Creek granites, but the appearance of the rock is rather different.

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At Silver Dell a fine granular base of quartz and felspar is present with quartz more or less in crystal form scattered throughout the mass, and imparting a semi-porphyritic character to the rock.

This granite has a dark vitreous appearance, owing to the great amount of cairngorm present.

A system of vertical jointings crosses this mass. These fissures are sometimes filled with greenish material, which appears to have permeated the country rock for a few inches distance from the fissures.

Zincblende and pyrites occur in abundance in these fissures, and are associated with silver and copper.

The amount of decomposition the granites have undergone is remarkable. It is difficult to secure a piece that will stand the process of preparation for microscopical examination. The felspars have become so kaolinised as to have lost almost all trace of cohesion, and in places the igneous nature of the rock is obscured.

The granite masses exposed in the Danjera and Yalwal Creeks by the partial removal of the Upper Marine sandstone cap, are identically the same as the granite eminences of the Permo-Carboniferous landscape, actual summits of which still lie beneath the sandstone.

Ever since that period the porous sandstone cap has readily permitted surface waters to attack the granite, without allowing the crust so decomposed to be removed. This would account for the generally rotten state of the granites, with the exception of that occurring at the bases of the deeper gullies.

Petrological Notes on some Yalwal Rocks.

The Basic Rocks.—An examination was made of specimens numbered 4,434, 4,436, 4,437, 4,439, 4,440, 4,442, 4,444, and 4,445 in the official register of rock specimens.

They represent rocks gathered from various portions of the field. In hand specimens they appear as greenish black compact rocks, varying from fine-grained basaltic varieties to coarse dolerites, and they may be grouped together as ophitic dolerites.

The base consists of lath-shaped felspars, with decomposed granular augite, iron ores, and needles of apatite. At times masses of exceedingly small felspars occur. The ground mass is generally finely holocrystalline. A glassy residuum, however, may have been present in certain instances, but owing to the great decomposition present, it is difficult to ascertain its existence.

Phenocrysts of felspar are rare, but in sections like 4,445, two crops of plagioclase are plainly visible, representing both intratelluric and effusive stages. The felspars are mostly of basic varieties, and are lath-like in habit. One slide represents large irregularly shaped phenocrysts, the contours being due to interpenetration growths. The first crop is represented by moderately sized plagioclase idiomorphs showing polysynthetic twinning. Broad twinning bands are present. Extinction angles, measured from the traces of the twinning planes, varied between 25° and 30°. This points probably to a basic variety, such as labradorite.

The second crop consists of abundant small lath-shaped forms.

Small idiomorphs at times appear partly enveloped by iron ores.

The ferromagnesian constituents are represented by augite, which is present both as phenocrysts and as grains in the base. All the members of the first crop are moulded on the felspars, thus giving rise to the ophitic

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structure (Plate IX). Under the influences of decomposition, the phenocrysts appear to be granular, but examination under crossed nicols proves the masses connecting the felspars to be in optical continuity.

In the coarsest dolerite examined some of the augite automorphs are as much as ½ and ¼ inch in length, and contain as many as a score of felspar crystals in one individual.

These rocks are very difficult to examine in detail, the original structures being masked by alteration products.

The felspars are changed to opaque products, through kaolinization.

The augites are corroded, and appear as grains or strings, or irregularly shaped masses, greenish and brownish-green in colour. Serpentine and chloritic products are invariably present. Long strings of the former traverse the body of the rock. At times the serpentinous products form concentric radial fringes in the amygdules, after the fashion of agate structures. The angite also, in conjunction with the plagioclase, alters to saussuritic products. Epidote is abundantly represented in field examination, and calcite occupies the majority of the original rock cavities, and shows the characteristic rhombohedral clearage and bright polarisation colours.

Ilmenite is well represented in the base. The Grassy Gully dolerites show squarish to rectangularly shaped iron ores, and decomposition is sometimes seen taking place along traces of cleavage planes. One mass, resulting from alteration of the ilmenite, posseses high refractive index, is transparent, and shows pinks and greens of high order under crossed nicols. This variety of leucoxene may be related to sphene. Inclusions of apatite also occur in the ilmenite. Secondary quartz is also common.

The Rhyolites, as determined by examination of rock specimens, numbered 4,429, 4,430, 4,432.

These were selected from lava flows along the Danjera Creek and Grassy Gully,† and they represent rocks yellowish-brown to blackish in colour, showing marked fluidal and spherulitic structures.

Large porphyritic crystals of felspar are plentiful, scattered through a very fine base. Associated with the porphyritic felspar are biotite flakes much decomposed.

These phenocrysts represent the intratelluric phase of crystallisation. The felspars are generally rectangular, but at times show corrosion by the magma. Polysynthetic twinning is common. The twinning bands are narrow, and at times the extinction is slightly undulose. This may be due to excessively fine twinning. The felspar is probably an acid variety of plagioclase.

Peculiar forms of twinning occur in some of the felspars of the older crystallisation. Opposite quadrants extinguish and brighten simultaneously in polarised light (Plate X). The appearance is possibly due to Baveno twinning. Inclusions also occur which are opaque and white, and may be due to the decomposition of ilmenite.

The ground mass of the rocks shows under crossed nicols the peculiar dappled appearance of crypto-crystalline aggregates. Flow structures are invariably present as straight or wavy lines. Less frequently, they present all the appearance of minute foldings with sharp anticlines and synclines.

Perlitic structure is well shown between the straight lines of flow.

The "flow" phenomena are specially well marked round the felspar automorphs, the appearance being similar to the "eye" structure noticeable in certain rocks.

Spherulites were not observed in the perlitic specimens, but in the rocks showing contorted fluxion phenomena, well-formed spherulitic growths

† For Grassy Gully rhyolites, see also J. B. Jaquet, *op. cit.*

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occupied the interspaces between the lines of flow. These are well developed and microscopic in size. This is known as the microspherulitic structure.

Along the bent lines of flow themselves the radiate growths occur in abundance. They do not start from a number of independent centres to form distinct spherical growths linearly arranged, but radiate from the contorted lines of flow themselves as axes. This is the axiolitic structure of Zirkel.

The finest examples of microspherulites, however, occur in a homogeneous looking felsite, in hand specimens almost devoid of the porphyritic element. The microspherulites themselves occur as patches of irregular shape set in a felsitic base. Under-crossed nicols the dark brushes of the tiny growths are arranged collinearly.

Some of these microscopic radiate growths have been replaced by quartz, secondary quartz is also very common, forming along lines of flow.

Iron oxide is common in red and brown stains.

Ilmenite is present, though not in great quantity. It is generally decomposed. Small zircons also occur.

Large spherulites are fairly common. They vary in diameter from $\frac{1}{8}$th to 2 inches. The lines of flow pass uninterruptedly through them.

The examination of these rocks points to a former vitrophyric condition, in which phenocrysts of an earlier period of consolidation occurred in a glassy base representing the effusive stage.

The base is cryptocrystalline (felsophyric) at present, but the great development of perlitic cracks points to former glassy conditions.

Divitrification in the case of the contorted flow-structure appears to have taken place as spherulitic and axiolitic growths. The non-association of the spherulites and perlitic growths is interesting.

Microgranites.—Determined by examination of rock specimens 4,428, 4,434.

The specimens described were chosen as typical examples from the Yalwal Creek, and the country rock of the lodes at Bundundah Creek.

These rocks are red to reddish brown in colour, and show idiomorphs of quartz and felspar plentifully scattered through a very fine but holocrystalline base. The individuals of this base are composed of quartz and felspar grains, which are roughly equidimensional, and show a tendency, in some instances, especially in the case of the felspars, to be idiomorphic. This matrix may then be described as hypidiomorphic granular. The rock is hypabyssal in character, and may be described as a quartz-felspar porphyry.

In the narrow aplitic tongues which pierce alike the dolerites and the rhyolites, the rock represents an almost simultaneous microscopic separation out of quartz and felspar. This is the micropegmatitic or granophyric structure. A decided tendency to graphic growth is observable in rocks from other portions of the field, the quartz showing characteristic six-sided skeleton crystals, the central portions being occupied by felspar.

The felspar of the first generation is represented by rectangular phenocrysts, $\frac{1}{8}$ to $\frac{3}{4}$ inch in length, much decomposed, and generally present as opaque white and pink kaolinised masses. In less decomposed examples, multiple twinning is frequently observed, pointing to plagioclase as the dominant felspar.

In rare instances, albite and pericline types of twinning, associated with quartz intergrowths, are exhibited by the same crystal. The crystals are coloured red and yellow with iron oxide, the edges being deeply stained at times.

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The felspar of the effusive stage is clearer than that of the earlier periods, and has a great tendency to form granophyric growths with the later quartz.

The quartz of the earlier stage of crystallisation occurs as bihexahedral phenocrysts. Corrosion has, however, been set up, and inlets of the magma occur in the peripheries of the crystals These phenocrysts vary from $\frac{1}{16}$ to $\frac{1}{3}$ inch in diameter, measured across the hexagonal sections. Inclusions are numerous, and arranged linearly. The base becomes much finer in texture as it nears the point of contact with these quartz idiomorphs.

Ferro-magnesian material is present as a few irregularly distributed green patches. It is pleochroic, and probably represents some decomposition product of biotite. Iron ores occur as ilmenite, weathering into leucoxene. Iron oxide is abundant, sometimes as inclusions in the viridite. Apatite is present.

A noticeable feature in the Yalwal granites is the absence of large felspar phenocrysts so common in the granitic rocks of New England.

Another point of interest is that while the granites, or granitites, of New South Wales are generally basic in character, containing (especially in the porphyritic types) abundant plagioclase, biotite, hornblende, sphene, apatite, and zircons, the Yalwal rock is characterised by its high silica percentage and its lack of basic constituents.

Rock specimen, 4,429.—This is a rock much like spherulitic pitchstone in hand specimens.

The bulk of the rock is composed of concentric growths about $\frac{1}{4}$ to $\frac{1}{2}$ inch in diameter.

The field evidence points to a tuffaceous origin.

Under the microscope, these structures are seen to consist of tiny flakes of hæmatite, with smaller quantities of limonite arranged concentrically, the long axes of the flakes being set parallel to the peripheries of the circles.

The base appears to be cryptocrystalline. The spheroidal growths are possibly expressions of weathering.

Economic Geology.

1.—*Alluvial Mining.*

The whole of the lower course of the Danjera and its continuance to the Shoalhaven as the Yalwal Creek contains alluvial gold, though not in great quantities

The majority of the gold found is fine in nature.

The whole course of the Yalwal Creek, as also many miles of the lower portion of the Shoalhaven, has been leased for dredging purposes.

The gold of the Danjera and Yalwal Creeks, being in a fine state of division, is difficult to recover by sluicing operations.

Saw-pit Gully (Plate III), a small watercourse draining the eastern part of the gold-bearing area, has, at various times, yielded a fair amount of gold.

The alluvial containing the gold consists of angular fragments of the associated Devonian strata and very large blocks of Upper Marine sandstone.

The gully is not of great age, the sandstone cap having but recently been worn through at this point, and the alluvial deposits of the stream postdate the degradation of the sandstone covering.

As the gold is, therefore, derived from the adjacent claims of the Caledonian, Bismarck, Usher, and Golden Quarry, one would naturally expect

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to find it but slightly rounded. It is generally coarse at this spot, one nugget weighing as much as 3 or 4 ounces. Other specimens varied in weight from 15 dwt. to 3 ounces.

Gold to the value of £2,500 was extracted from the Sawpit alluvial in 1893.

Alluvial has also been worked at Grassy Gully, its discovery leading to the working of the Grassy Gully Reef.

(2.) *The Lodes.*

As far as at present known, no reefs with decided walls exist in the Yalwal district.

In 1883, Mr. Pittman,† Government Geologist, declared that the ore deposits were of the nature of impregnations in stratified rocks. Since then mining developments have done nothing further to indicate the existence of pronounced fissure veins.

The gold-bearing area proper is confined to a hard belt of rocks immediately south of the village of Yalwal, and occupies both east and west banks of the creek.

These sediments consist of quartzites, conglomerates altered in places to quartzites, schists and slates.

The greater number of workings occur on the eastern bank of the creek, those on the western bank being confined to a few blocks known as the Eclipse, Pinnacle, and Poor Man Claims.

Three large belts of conglomerate pass through the field.

One "makes" strongly through the Usher tunnel, across the Saw-pit Gully, and into the Golden Crown property.

Another and parallel belt emerges from the sandstone immediately to the east of the Homeward Bound open cut, thence through the eastern pegs of the Pioneer, across the Danjera Creek, as the "Buck Reef," Plate III, or "Mother Lode," and clean through the Pinnacle and Eclipse leases, leaving the latter property at the mouth of the No. 2 tunnel. Thence, with varying dip, it passes to the north.

These conglomerates consist of black and grey quartzite, slate and quartz pebbles, set in a fine siliceous cement. They have been so altered in places as to have lost all trace of their pebbly origin. The first stage in their metamorphism consisted in the reduction of the whole to a quartzite in which the matrix and enclosed pebbles are almost indistinguishable.

Further stages are marked by masses of impure quartz, all traces of pebbles having vanished.

The softer strata between the conglomerates, as also those beneath them have been subjected to great crushing.

All this line of country is auriferous in a greater or lesser degree.

Large low grade deposits have been found closely associated with the conglomerates, *e.g.* Golden Crown, Usher, Hidden Treasure, Pinnacle, and Eclipse claims.

These conglomerates are probably connected with less altered beds in the Jinkbilly Creek. In the latter locality, epigenetic agencies have not had nearly so much influence on the strata, the nature of the pebbles and the cement, as also the strike and dip being evident at a glance. Curious alteration products are observable in the Golden Crown and Pinnacle claims. A rock of felsitic appearance occurs in the lodes of these properties in great abundance, being as much as ten yards in width near the surface of the

† Annual Report, Department of Mines, 1883, 159–160. *Vide* also, The Mineral Resources of N. S. Wales, 1901, p. 59.

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SOUTH END OF HOMEWARD BOUND OPEN CUT.

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Pinnacle workings. It is, however, so soft that it can be scratched with the finger nail. It is whitish, brownish, and occasionally bright green in colour, being also in the latter case translucent, and of an oily appearance resembling pargasite.

Rarely it has the appearance of certain dolomites. In these cases it contains small radial aggregates.

Threads and lenticular bunches of quartz intersect it in all directions. Frequently also it is intimately associated with a dense, hard, siliceous rock resembling impure quartz.

Throughout these soft and hard silicate masses, large bunches of pyrites are capriciously distributed; there are also innumerable black strings representing oxidised pyrites.

Below the water level these formations contain huge masses of iron and arsenical pyrites, with white quartz. In the case of the Pinnacle, the Eclipse, and the Golden Crown, the "formation" is crossed with numerous slides, some of which have been mistaken for true reef walls, as "Reynolds' Hanging Wall"—a slide in the Eclipse.

The Homeward Bound, Pioneer, and Star leases represent the western portion of the auriferous area. The former two are worked as large "open cuts" or quarries, all the quarried matter passing through the batteries.

References to the diagrams shew the quarries to be contained in quartzites, iron-stained slates, possessing various dips, and traversed by slides.

The mass of strata worked for gold in the west is intersected with innumerable quartz-veins or "stringers."

Although these properties are not so intimately related to the conglomerates as the eastern leases, they may nevertheless be considered as associated with them, inasmuch as their strike is almost coincident with the western belt of conglomerate, and their distance apart is insignificant.

In the Caledonian property, a closer approximation to true veins is found. The strata here vary in dip from 30°–60° to the north-west and west-north-west. Narrow veins of chalcedonic quartz run across the "combs" of the country. These, however, appear to have no depth, and, as far as at present proved, pinch in and out with wonderful rapidity.

The quartz of the field is generally very impure, being for the greater part of the chalcedonic variety, bluish to grayish in colour, and weathering into products having the appearance of whitish and yellow clays.

Opaque white quartz occurs associated with the pyritic masses of the conglomerate area.

The bulk of the soft material in the lodes appears to be derived from crushing of the strata.

The only important constituent of the lodes is gold.

It is marked by its occurrence in an extremely fine state of division. Similar occurrences are noted from Wyalong* and Pambula.†

Free gold occurs in the oxidised zones, but, as far as at present known, not in the sulphide zones. The pyrites of the sulphide zone yield on assay from 2 to 24 dwt. of gold per ton, the bulk of the mineral being of poor quality, rarely exceeding 2 dwt. per ton. This information was supplied by the mining men of the field.

The surface gold was contained in a variety of gossan, and was at times coarse in nature. Throughout the lode the gold occurs in irregularly distributed patches, and as films coating divisional rock planes. Very often no trace of the gold is to be seen in the solid rock between these gold-covered jointings.

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* J. A. Watt, Min. Resources, No. 5, p. 19. † J. E. Carne, Ann. Rpt. Dept. Mines, 1896, p. 116.

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From this it seems evident that the sulphides contained the gold, and that surface waters reduced the auriferous pyrites to iron-oxide, free gold, and various soluble products.

At Grassy Gully the auriferous belts occur in felsite formations, traversed by thin quartz veins. Gold is found in a finely-divided state on the joint faces of the crushed felsite.

Three miles to the north of Yalwal, along the Yalwal Creek, the granite has surrounded a mass of basic rock. A white variety of quartz occurs in the granite near the junction of the two rocks. Silver has been found at this spot.

In the Right Arm (Bundundah) Creek, silver, lead, and copper have been mined for in granite.

The minerals occur in joints and fissures, which are traceable over considerable distances in an approximately north and south direction.

The vein material is at times greenish in colour.

Copper associated with zinc-blende and pyrites has also been found in the dolerites. Granitic dykes occur in close proximity to this lode.

The Genesis of the Deposits.

It is very probable that the intrusion of the Carboniferous (?) granites and micro-granites formed the most important factor in the folding of the Yalwal district.

These foldings were accompanied by intense local deformations

The axes of the foldings coincide with the strike of the beds, and the ruptures forming the lodes appear to follow the lines of greatest weakness. This is plainly seen in the Homeward Bound, Pioneer, Pinnacle, Eclipse, and other auriferous belts.

The cooling of the eruptive masses was also attended with crushing owing to the shrinkage of the mass.

The soft green-and-white lode products are, doubtless, due to the crushing of the softer strata against the harder belts, the nature of the material so derived being modified subsequently by mineralised waters.

Innumerable shrinkage cracks were developed in the strata, which had been twisted into sharp anticlines and synclines. Into these cracks quartz, auriferous pyrites, and other minerals were introduced by circulating waters.

The faces of the joints and faults were also charged with gold in the same manner.

The Caledonian deposits admit of a similar explanation, although here the "reefs," which are larger than the "stringers" of the Homeward Bound, do not follow the strike of the country, but break across it. They are, however, very limited in extent, and represent slight ruptures in the harder and more compact rocks, which crossing the "combs" of the country, were allowed to remain open until filled with chalcedonic quartz. It is very probable that these lenticular masses of chalcedonic quartz, containing rich gold patches may exist in other portions of this belt of country. A single tunnel cannot be expected to prove the ground entirely, as these small veins pinch in and out with great rapidity.

Similar conditions appear to have obtained at Grassy Gully. Here, however, the disturbed rocks consist of rhyolites and dolerites.

Grassy Gully reef appears to lie along a line of crushed rhyolite. The fragments resulting from crushing have been cemented by quartz, and the breccia itself is traversed by very small quartz veins.

The general appearance is that of local crushing, which took place along meridional lines.

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This brecciation in certain cases may be due to the opening of fissures, and subsequent movement of the walls on one another.

Other occurrences are at times suggestive of "crush breccias," the fragments being subsequently cemented by silica and tiny veins of chalcedonic quartz developed throughout the mass.

The gold occurs in joints throughout the formation of crushed rhyolite, and is found both in the igneous rock and in the quartz.*

It is associated with pyrites and occurs in a very fine state of division, as at Yalwal. Rich specimens at times consist of rhyolite masses having thin coats of gold on one or more sides determined by rock joints, the rock between the cleavages being absolutely barren of the auriferous material.

It appears then that the Yalwal district was much contorted, that the contortion or movement was of considerable duration, during which fissures opened along the lines of maximum weakness (the axes of the folds) and were closed again, a grinding action ensuing, the outward and visible signs of which are the various lode formations; and that innumerable cracks sent their tiny ramifications through the mass as a result of the above mentioned forces and also of the shrinkage due to settling down of the disturbing agents; and that highly mineralised waters circulating through the mass deposited gold bound up in pyrites.

Description of Mining Properties.

The Pinnacle.

This claim, known also as No. 1, lies on the north and south line of the crushed formation that follows the belts of conglomerate. The lode is exceedingly variable in width, and is apparently due to the metamorphism of the associated conglomerates and intercalated beds. The alteration products at times have the appearance of felsites. They can, however, be scratched with the finger nail. Quartz occurs throughout this "formation" generally as white opaque varieties, in irregular patches, as though filling cracks in the soft crushed mass. Throughout the lode, also, black oxidised pyritic bunches occur in the same irregular manner. These, at about a depth of 100 feet from the cap of the lode, make into large bunches of pyrites. Their assay value is very low. In other places the formation consists of a dense, opaque, iron-stained siliceous material, resembling an impure quartz.

The country consists of mudstones, shales, quartzites, slates, and siliceous schists, having a general north-east dip, varying from 30° to 50°. This dip, however, exhibits numerous variations from the general north-east direction, indicative of minor crumplings superimposed on a general fold.

The methods of working adopted consisted of excavating the top to a width of nearly two chains, and a corresponding length along the line of strike, and a depth of about fifty feet. A floor was here left, and beneath this again another large excavation was made, connected with the upper workings by passes. This bottom chamber narrows at about 100 feet below the cap to eleven yards in width. Two tunnels are driven into it from the hillside, near the battery.

The upper one is some 100 feet in length, and passes through beds containing *Lepidodendra*.

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* J. B. Jaquet, Records Geol. Survey, 1900, vii., p. 17.

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The lower one, some 60 yards in length, is the main outlet for the ore passing to the battery, and is cut out of the creek bluffs at 45 feet above the water. This lower tunnel has been continued through the workings for another 100 feet to prove the country west of the lode.

The battery in use consists of fifteen head of stampers, 800 lb. each in weight. It is attached by gearing to a Robey engine of 20 h.p., worked with a multi-tubular boiler. A Jacques rock-breaker is employed, as also automatic feeders. Two Berdan pans and Huntingdon mills were originally in use, but have since been discarded.

The gold returns were furnished by Mr. J. Sievewright, and represent a few of the better yields from this, the pioneer property of the field.

Gold Returns.

Date.	Tons crushed.	Oz. of gold.
May–Sept., 1872	.....	118
Nov., 1872–March, 1873	80	120
1874	220	330
1875–1878	Returns lost.	700 (?)
May–Dec., 1878	315	382
Jan.–Feb., 1879	53	115
April–July, 1880	280	670
March–Nov., 1881	1,406	282
Feb.–Oct., 1882	341	69
Total from 1872–1882	.....	2,786

The Eclipse.

This property, also known as No. 2, joins the Pinnacle to the south, and appears to be continuous with it. The workings of both properties open freely into each other, and give the idea of a series of gigantic caves, superimposed one above the other, and connected by narrow passages.

The uppermost workings exist (as described for the Pinnacle) in the form of an open cut, terminated below by an irregularly shaped floor. Below this, however, still larger caverns exist, with attached side caverns, and below this again another series of chambers.

Some of these are as much as fifty or sixty feet in height, fifty feet in length, and thirty to forty feet in width. The total depth of the Eclipse series of chambers is 160 or 170 feet. Recently mining operations have been revived in this property, and the top floor, in the immediate vicinity of "Reynolds' Hanging Wall" (a joint-face mistaken for a true fissure wall), has been blown away by explosives, and exposes a cavern 100 feet in depth. Some of the individual shots used in blasting the material, forming the floor between the uppermost and middle chambers, brought away over 100 tons of stone.

The whole of the material left by stoping operations presents a dangerous appearance. Fragments of rock, several tons in weight, project loosely from the walls. Under the present management, however, these are being removed, and the workings will henceforth be safe to work in.

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PINNACLE AND ECLIPSE CLAIMS. FROM THE NORTH.

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What has been said concerning the Pinnacle applies with equal force to the Eclipse, except the presence of the soft-green crushed material. The country is harder in the Eclipse than in the neighbouring property.

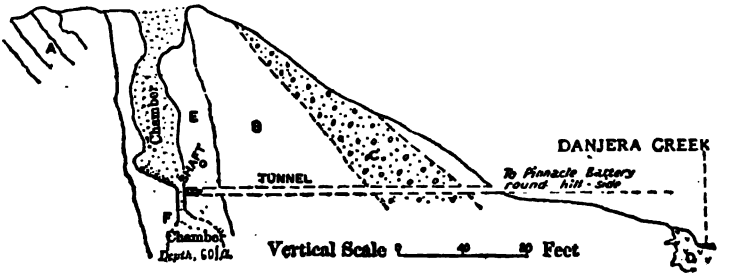
The workings are also much deeper.

A large chamber, fifty-five feet deep, and of almost equal length, exists in the Eclipse below the bottom level of the Pinnacle. Two shafts, also some sixty feet deep, were sunk in the lower level. Much of the work was carried on in solid pyrites and opaque white quartz.

A small tunnel has been driven near the top of the workings, to afford an outlet for the ore of the open cut.

A lower tunnel was driven in the hill-side to prove the northern side of the property.

Sketch Section Illustrating the Method of Working "The Eclipse Mine."



Reference.

A.—Contorted slates.
B.—Hard siliceous rocks.
C.—Altered conglomerates.
D.—Intrusive dolerite.
E.—Much oxidised pyrites.
F.—Much arsenical and iron pyrites.

Note.—The Pinnacle tunnel, as indicated above, is projected into the same plane as the Eclipse workings. There are no defined boundaries to the lode as shewn in the section.

An almost circular route was taken with the open cut as goal.

This tunnel was used to convey the ore to the battery.

At present, however, the two properties (Pinnacle and Eclipse) have been amalgamated, being the property of Mr. Alex. Hay. The stone in the vicinity of Reynolds' Hanging Wall is broken down, passing over a large tip in its fall into the Pinnacle claim, whence it is trucked along the lower tunnel (Pinnacle) to the Eclipse battery, as the Pinnacle battery, a larger and much better plant, is slightly out of repair.

The Eclipse battery [Plate VI] consists of ten head of stampers, each 600 lb. in weight. Punched screens and copper amalgamating plates are in use. The battery is connected with a portable Robey engine, of ten horse-power, by bevelled-gearing.

The tailings passed into settling pits, and were then turned into vats to undergo the cyanide process. Two leaching vats were used, each ten feet in diameter, with a working depth of four feet and a capacity of nine tons. This plant is not used at present.

Good crushings have been obtained from the mine during the last few months.

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The following gold yields of the Eclipse Mine were kindly supplied by Mr. John Maclean, of Nowra, and date from 15th May, 1878, to 14th July, 1889 :—

Date.	Tons Crushed.	Oz. of Gold.	Amount.
Results as per Mint Proceeds during Suffolk's Tribute.			£ s. d.
14 May, 1878, to 30 December, 1878	.....	.....	155 1 0
14 March, 1879, to 15 April, 1879	.....	.....	92 19 0
Results obtained by Eclipse Gold-mining Co.			
October, 1879, to 22 December, 1879	161	264·73	896 14 0
14 February to 23 December, 1880	376	573·84	1,895 3 0
22 July ,, 22 ,, 1881	1,034	801·00	2,795 3 0
4 March ,, 10 August, 1882	851	307·66	1,015 10 0
27 June ,, ——— (?) 1883	160	230·00	578 13 0
4 April ,, ——— (?) 1884	100	95·06	330 0 0
10 November ,, ——— (?) 1885	.....	.....	120 19 0
6 August ,, ——— (?) 1886	.....	.....	502 2 0
14 June ,, 14 December, 1887	.....	.....	1,751 11 0
20 January ,, 14 November, 1888	.....	.....	703 7 0
27 March ,, 26 July, 1889	.....	.....	964 0 0
Total till July, 1889	.....	.....	£11,543 2 0

The following averages represent a nine months' continuous crushing, *i.e.*, the averages of the monthly percentages of the total amount of stone mined and treated during that period (prior to 1889) :—

	s.	d.	
Mining	1	8½	per ton.
Crushing	1	7½	,,
Fuel	0	9⅜	,,
Stores	1	0$\frac{1}{12}$	,,
Approximately (mine to Mint)	5	2$\frac{11}{24}$	

The Pioneer Claim.—This property consists of three open cuts of large size, a lower tunnel 950 feet in length, an upper tunnel some 450 feet in length, and a fine battery situated about twenty-five feet above creek level.

After being worked for a while at the surface, shafts were sunk on supposed reefs. The gold, however, being discovered in "stringers" throughout the country, it was found advisable to adopt the quarry or open cut system.

In all there are three open cuts, Nos. 1, 2, and 3.

Nos. 1 and 2 open cuts are about fifty to sixty feet deep in very unsettled country, the strata having suffered much from crushing.

The material from these open cuts was conveyed to the battery by means of a short tunnel driven in from the hill-side, and by a pass connecting with the main tunnel.

No. 3 open cut is larger than Nos. 1 and 2. It is continuous with the Homeward Bound workings, and its floor is about fifteen feet lower than that of its neighbour. It is also of more recent date than the other Pioneer workings. The ground is also more settled, the beds having a general west-north-west to north-west dip, varying from 30° to 40°.

A fault runs along the eastern boundary and disappears in the wall about half-way along the quarry's length. The beds of this open cut may be seen to cross the north and north-west ends of the Homeward Bound open cut.

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PIONEER BATTERY. FROM THE NORTH.

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Mr. J. Hanson purchased this property in 1890, and became sole proprietor He drove a tunnel into the hill from a spot not far removed from the site of the present battery. This tunnel was driven with the double object of conveying the stone to the battery and proving the existence of any lodes.

Its course is straight for some 8 chains, thence under the open cuts its course is sinuous. It is 130 feet below the floor of No. 3 open cut, and passes connect it with the various workings.

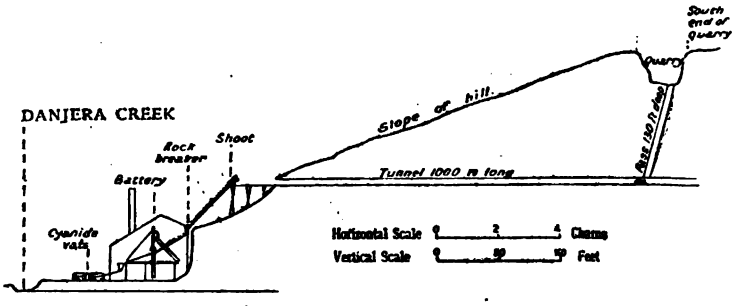
The strata passed through consists of curly and siliceous slates, quartzites, etc. Small quartz veins cross the directions of the bedding but appear to be only slightly auriferous.

On completion of the tunnel in 1891, a forty-head battery was erected (Plate VII). Each stamper is 900 lb. in weight, and works at from sixty-five to seventy drops per minute. Punched screens, and copper plates (twelve to fifteen feet in length) are in use. A giant rock-breaker, fifteen inches by nine inches, is employed as also Challenge automatic feeders.

The battery is driven by gearing from the engine, which is of the compound condensing type of eighty I.H.P., and giving seventy revolutions per minute.

Two boilers are in use, made by the Otis Co. of Melbourne from Batcox and Wilcox pattern.

SKETCH SECTION OF "PIONEER" WORKINGS, ILLUSTRATING THE METHOD OF SENDING ORE TO MILL AND CYANIDE PLANT.



The diagram illustrates the method of conveyance of ore to the battery. The stone is sent down a pass 130 feet in depth to trucks running on a slightly inclined tramway to a shoot, whence the ore is conducted into the rock-breaker and thence to the battery.

The cyanide plant which was erected in February, 1898, is worked on the New Zealand plan, and consists of three solution tanks. Two of these are each of fifteen feet diameter and six feet working depth. The other is ten feet in diameter and six feet in working depth. The leaching vats are five in number. Four of these are twenty feet each in diameter and of four feet working depth. The capacity of each is sixty tons. The remaining vat is fifteen feet in diameter and of forty tons capacity. These vats are fixed on a concrete foundation. No upward current of water is used whereby to minimise the deleterious effects of the slimes, but instead Spitzkastens are attached to the end of the amalgamating tables.

Lime is employed as the neutralising agent, 2½ to 5 lb. being used to each ton of tailings. Three precipitation boxes are used to recover the gold. A complete assay plant is attached to the battery.

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The gold returns for individual years are not available, but the total amount won from the inception of mining operations until the end of August, 1895, was £24,000.

In 1896, 9,664 tons of stone were crushed for a yield of 454 ounces of smelted gold.

Since that time very little mining has been carried on.

Homeward Bound Claim.

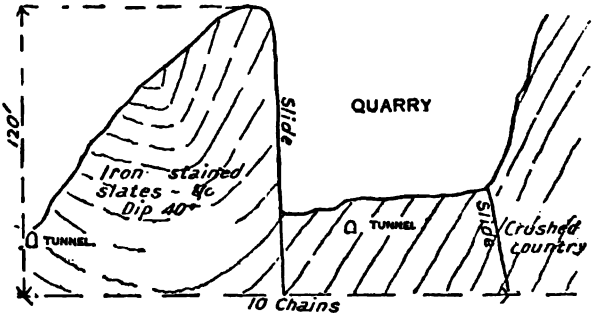
This property is the only one on the field that has been worked continuously for the past three years.

The property consists of two gold leases, containing nearly fifteen acres and two mining tenements.

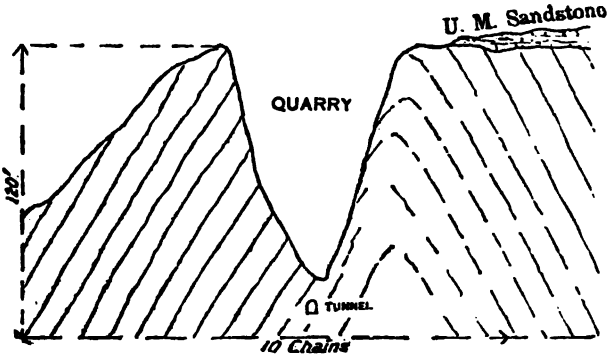
About the year 1872 the surface of the present Homeward Bound Claim was prospected for gold. Shafts were then sunk on supposed quartz veins and stoping afterwards carried on to such an extent that the various workings became connected. The cap was then broken down, and mining operations have since been confined to the formation of a large open cut.

A glance at the plan and sketch sections of the workings reveals the varying dips of the strata.

SKETCH SECTIONS ACROSS "HOMEWARD BOUND" CO.'S QUARRY.



Section from W. to E. through middle of quarry; dip slightly exaggerated; no reefs are visible.



N.N.W. and S.S.E. section through S.W. corner of quarry, showing possible anticline, signs of which are visible from the south; no reefs showing.

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At the north-west and north-east extremities, the prominent dips noticeable in the "Pioneer claim" obtain, viz., north-west to west-north-west at angles varying from thirty to forty degrees. The dip then rises rapidly to the south-west and near a fault on the western boundary is north-west at sixty-five degrees.

At the extreme south-west portion there is evidence of a small anticline among the slaty rocks, the beds at this spot dipping in an easterly direction at thirty degrees.

A slide (fault) occurs alongside the eastern wall of the open cut. This also passes into the "Pioneer" claim and has influenced the beds there. The ground immediately to the east of this fault is much crushed, the rock dips not being recognisable.

The open cut is rectangular in plan. At the surface the length is about four chains, and the width three chains.

The batter of the open cut is about sixty degrees, although in places slides have caused the walls to assume an almost perpendicular appearance.

An anticline occurs between the open cut and the mouth of the tunnel.

The open cut is 100 feet in depth at the southern end, but tapers away to the north owing to the hill slope.

Throughout the whole of the excavation there is no sign of a decided reef, the gold occurring in small quartz "stringers" scattered in all directions throughout the country.

In 1891 a tunnel was driven into the hillside to facilitate the conveyance of the ore to the battery below.

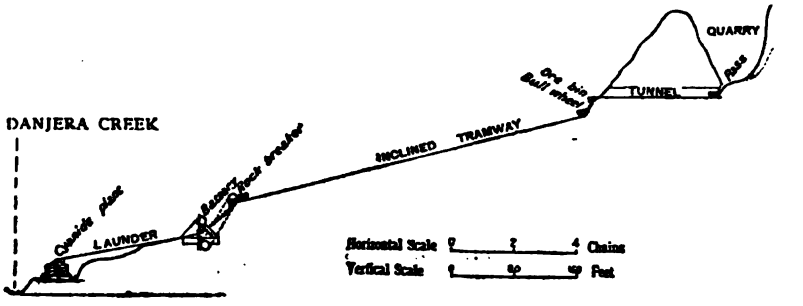
The walls are broken down and trucked to one of the several passes in the floor of the workings; thence they pass to the tunnel twenty feet below and are trucked by horses to the ore bin. Here a bull wheel enables the trucks to be sent down an inclined tramway by the force of gravitation alone.

The inclination of this tramline is from eleven to fifteen degrees, and its length is 200 yards. The stone is tipped into the rock-breaker and passes thence through automatic feeders into the battery.

The tailings are conveyed directly from the amalgamating plates by a launder to the cyanide plant.

This method of procedure is explained by the sketch section.

SKETCH SECTION SHOWING METHOD OF SENDING ORE TO BATTERY BY GRAVITATION, "HOMEWARD" BOUND G.M. CO.



The battery in use consists of forty head of stampers, each 900 lb. in weight, also ten head of stampers, each 700 lb. in weight. The average speed is seventy-two drops per minute. Punched screens (190 holes to the

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inch) are in use and copper amalgamating plates. (Plate VIII.) The battery is driven by a horizontal, high pressure, non-condensing engine, having a cylinder of twenty inches diameter and a stroke of forty inches.

The two boilers are multitubular, twelve and fifteen feet respectively in length, and six and a half feet in diameter.

A Worthington Duplex pumping engine is employed.

The following notes on the cyanide plant were supplied by Mr. A. F. Mixner, General Manager of the "Homeward Bound" Gold-mining Company.

The vats (leaching) are nine in number having a total capacity of 350 tons. Five vats are of thirty tons, and four of fifty tons capacity.

The diameters are twelve and fifteen feet respectively and the working depth of all seven feet three inches.

Owing to the hilly character of the locality the plant had necessarily to be constructed with the solution vats and zinc precipitation boxes on the high ground, and by this arrangement the solution has to be pumped to the zinc boxes for the extraction of the gold. The pump works the three solution valves (alkaline wash, strong and weak solutions) with the one piston, and the amount of solution required to be lifted is regulated with bye-passes connecting the delivery pipe and the collecting pumps, so that the solution running with the greatest strength governs the speed of the pump) and the bye-passes are opened to such a degree as to compensate for the suction of the other two. The tailings are conveyed to the cyanide plant by a wooden launder and iron pipe. From the main sand pipe, each vat is connected by a separate pipe leading into a distributor, the height of the sand launder being nine feet above the vats. Under the launder the solution pipes are placed, each vat having its own connection with the same, and in such a way that the solution can be either applied to the top or forced in from below, this being one of the advantages gained from the situation of the solution vats.

The solution connections are simplified by the arrangement of three-way valves leading from the main, and also a two way valve at the side of each vat, acting so as to divert the current of the solution either up or down into the vessel. This solution pipe is also connected with a three inch water main so that the water can be applied in a similar manner.

Great difficulty was at first experienced owing to the slimy nature of the pulp, and it has been found advantageous to apply an upward current of water whilst the vat is being filled. Thus the slimes are borne upwards over the vat rims, and a free leaching pulp remains.

The treatment.—The principle of the process is continuous percolation.

Filling takes place at the rate of one ton and a half per hour.
Draining water from tailings occupies eight hours.
Treatment with alkaline wash occupies twenty-two hours.
" " strong solution occupies seventy-two hours.
" " weak solution occupies ninety hours.
Draining after weak solution occupies eight hours.
Discharging residues occupies three to four hours.

The strength of the strong solution varies from ·26 to ·3 per cent. of potassium cyanide (KCY). That of the weak solution of potassium cyanide varies from ·14 to ·18 per cent.

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HOMEWARD BOUND BATTERY AND CYANIDE PLANT.

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The alkaline wash required is made up with ·8 lb. alkali to the ton of tailings treated. The effect of this wash is to neutralise the natural acidity of the tailings.

After the alkaline wash the strong solution is applied, and then the weak.

The clean-up is conducted in the ordinary manner by rubbing the deposit off the zinc filament, drying and roasting with ten per cent. of nitre, then fluxing with borax, soda, bicarbonate and manganese dioxide, under which treatment a rough bullion of a value of fifteen shillings per ounce results.

This is refined and is forwarded to the bank having an average value of about £3 per ounce, whereas the native gold of the mine is worth about £3 5s. per ounce. The alloy is silver.

Generally speaking the amenability of the ore to cyanide treatment allows of a very cheap method of treatment. This smallness of cost is further accentuated by the fact of the porous nature of the material acted on, allowing a coarse (120 holes to the inch) screen to be used.

The precipitation in the cyanide treatment is by zinc filaments. Four boxes are in use, each 13 feet 6 inches long, 2 feet 6½ inches wide, and 2 feet 2 inches working depth. There are nine working compartments in each.

The consumption of zinc per ton of tailings actually treated is ·75 lb.

The average percentage of extraction by amalgamation is 40 to 44 per cent., and the extraction of gold from the tailings by cyaniding ranges from 66 to 84 per cent., according to the value of the material under treatment, and this value varies from 30 grains to 4 dwt. of fine gold per ton.

The plant is almost automatic, one lad in each shift doing all the work.

A considerable space has been devoted to this cyanide treatment at the Homeward Bound, but the simplicity and cheapness of treatment coupled with the fact that the cyanide plant saved the mine when recovery by amalgamation was rapidly approximating to a negligible quantity, justifies the extra space given up to its description.

The percentage of extractions is:—Milling, from 15 to 47 per cent.; cyaniding, from 50 to 84 per cent. The cost of treatment per ton at this mine is as follows:—

	s.	d.
Mining	2	0
Explosives		4·68
Fuel	1	6
General Stores		1·90
Up-keeps and Repairs		9·16
Milling	1	7
Cyaniding (including smelting, refining, assaying, etc.)	3	0
Total	9	4·74

The foregoing figures are averaged from 30,000 tons of stone treated. Twenty-eight men are employed in the mine; in the mill three men and three boys, three stokers, and two others.

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Gold returns of Homeward Bound Mine.

(1.) From crushings dating from 1882–1889, with a 10-head battery.

	Silver.	Gold.
	£ s. d.	£ s. d.
June 1—August 29, 1882	6 18 4	575 18 11
March 4—December 20, 1883.....	29 12 3	2,555 17 9
January 6—October 3, 1884	26 1 6	2,051 7 6
May 8—October 3, 1885	68 17 5	5,133 11 9
January 15—December 24, 1886 ..	.....	3,564 7 0
February 18—December 6, 1887...	60 13 11	6,105 10 0
January 10—December 6, 1888 ...	25 14 3	5,478 2 11
February 7—July 24, 1889	.....	2,196 2 3
Totals	216 18 8	27,650 18 1
		216 18 8
Total	.....	27,867 16 9

(2.) Later returns, dating from 1890–1900.

June, 1890—April, 1897 (from August, 1894—February, 1897, the mine was not worked owing to litigation) 9,804 oz 10 dwt. 20 grs. of gold were recovered. Average value £3 4s. 9d. per oz.

From September, 1898, to December, 1900, 37,898 tons crushed, and 13,371 tons cyanided. The gold won by amalgamation amounted to 3,723 oz. 2 dwt. 20 grs. (Standard gold) 762 oz. of silver were also won.

From cyaniding, 1,570 oz. 5 dwt. 15 grs. of gold recovered at value of £4,229 8s. 3d.

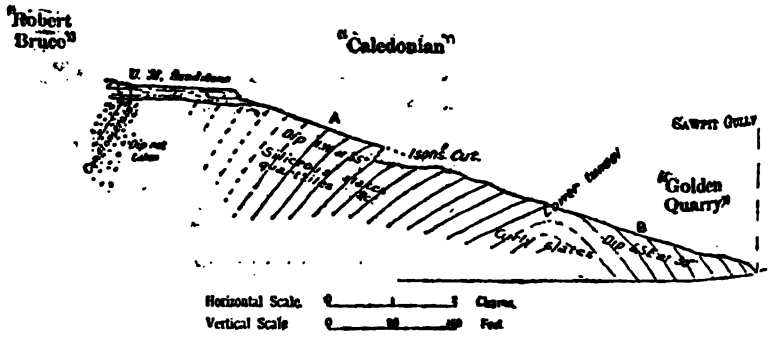
The Caledonian Property.

This is the claim from which all the sensational gold finds have come. The property is also known as G.L. 20, and is twelve acres in extent. The Permo-Carboniferous sandstone forms a cap over the whole claim except over a small patch at the north-west corner.

The workings consist of two tunnels, one being 100 yards in length, and a few open cuts about a couple of yards in width, varying in length from one to four chains, and in depth from ten to fifty feet.

It will thus be seen that the ground is by no means proved as yet.

SKETCH.—SECTION ACROSS THE CALEDONIAN PROPERTY FROM THE ROBERT BRUCE CLAIM E.S.E. TO THE GOLDEN QUARRY CLAIM AND SAWPIT GULLY.



NOTE.—The ground from A to B shows numerous irregular fissures (especially near the summit of the anticline) filled with chalcedonic quartz.

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The gold is confined to small chalcedonic quartz veins crossing the combs of the country. The enclosing strata consist of siliceous and curly slates, quartzites and conglomerates dipping north 60° west at angles varying from 15° to 65°.

In the lower tunnel the strata dip in opposite directions at the two ends of the drive. This shows the existence of an anticline immediately to the east of the workings.

The gold occurred in patches of exceptional richness, as explained by a perusal of the gold returns.

The open cuts, whence the gold was won, were driven on small veins. They are named as follows:—

1. *Sandeman's Cut.*—This is 100 feet in length, thirty feet in height, and having a direction of 220°.
The gold was found in "stringers" of bluish and whitish quartz of felsitic appearance. The underlay of the vein is about 10°.

2. *Underwood's Cut.*—This is one chain in length and about thirty feet in depth. Nearly £40,000 of gold were said to have been extracted hence.

3. *Ison's Cut.*—Occurs one chain north of Underwood's Cut. The length is some four chains, and it has a direction of 230°.
A line due north and south connects the mouths of the various cuts.

Gold Returns.—Only a few of the better returns were obtainable, the total amount of gold not being known—

	£
1892. (Three months' crushing)	3,500
1895. 27¼ tons for 1,487 oz.	4,833
1895. 1¼ „ 750 „	2,438

Original company since that time obtained more than £6,000 worth of gold in a few months.
It is also stated that in the year 1895, 4 tons of stone yielded 1,664 oz. of gold.

The Star.

This claim was taken up in 1883 by a Nowra syndicate.
It occurs on a very rough sideling.
Three tunnels have been driven at various levels into the hillside, with an almost due east direction. They are driven as closely as possible to the Homeward Bound property, and they lie vertically one above the other.
The upper one is 200 feet in length and 400 feet above the creek, the middle 350 feet in length, and the lower 450 feet long.
This lower tunnel is driven almost at the creek level.
In the two upper drives a little gold was found.
The country consists of siliceous slates principally, that show an easterly dip. Small quartz veins cross the property.
This claim lay idle for years. In 1900 it was taken up by Mr. H. Martin, and subsequently amalgamated with other leases belonging to Mr. A. Hay.
In September, 1900, four tons of stone were crushed for a return of 5 oz. 7 dwt. per ton.
Shortly afterwards, a parcel of 100 tons was made up and crushed at the Pioneer battery. The yield was a little less than 10 dwt. per ton.

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The Golden Crown.—This property, also known as G.L. 1., occurs in much altered country in close association with the conglomerate belts. An intrusive sheet of dolerite occurs immediately to the east.

The country has been subjected to great crushing and extreme silicification, the latter possibly through the agency of heated mineral waters.

The soft magnesian silicate rock with the appearance of felsite is of frequent occurrence. Here much of it occurs in patches of bright green translucent to almost transparent masses.

The workings consist of an open cut at the base of which is a shaft about ninety feet in depth. A tunnel nearly sixty-five yards in length was driven in the hill from Sawpit Gully to connect with the various workings.

Great quantities of pyrites occurred in the lower portions of the workings.

The Usher.

This property is known also as G.L. 17. It contains a tunnel 230 feet in length driven towards the western boundary of the lease. After passing through slates, a belt of soft conglomerate was encountered.

A shaft was also sunk on the hill side to a depth of forty feet. The mass of the material driven through consisted of oxidised pyrites, associated with quartz and conglomerate

The pyrites on assay are said to yield 24 dwt. per ton.

Golden Quarry (*Nos.* 1 *and* 2).

G.L. 27 and 28. Golden Quarry No. 1 has a shaft sunk thirty-three feet east of G.L. 19 and thirty-four feet deep. A cross-cut fourteen feet long was driven on a formation six feet in width.

A tunnel also 208 feet in length was driven west from the level of the gully.

In 1896, 113 tons of stone extracted from both claims were crushed for a yield of 188 oz. 8 dwt. of gold.

The Victory.

The country is much altered, intense silicification having occurred in the slates and other rocks. Many of the strata now consist of quartzites. A hard belt of country occurs in this claim which is being mined for gold. A tunnel has been driven through the property for a distance of 500 feet.

This property is situate between the Pioneer and Pinnacle Claims.

The Poor Man.

This claim was prospected for gold in 1880, and then taken up. The country consists of narrow belts of quartzites, slates, and shales, much bent, crushed, and faulted.

The workings consist of a large open cut, and a tunnel a couple of chains in length.

Gold was found on the faces of the rock joints. The occurrence of the metal was extremely irregular, as in the cases of the other Yalwal claims.

No account was kept of the better gold returns. In 1896, 311 tons of stone were crushed for 75¾ oz. of gold.

Other minor Properties.

These consist of properties, such as Baberton's lease, Sir Julian's Leg, The Albion, The Coolongatta, The Daydawn, and The Bruce.

Baberton's Lease—This occurs in crushed and faulted quartzites and shales to the north-west of the Poor Man. An open cut was started.

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The Albion (G.L. 26).—This contains a drive, 130 feet long, and also a cross-cut. Much pyritic material was found here.

The Coolangatta (G.L. 39) gave good prospects, and contained much pyrites.

The Daydawn (G.L 23).—A tunnel, 100 feet long, has been driven in at the level of Sawpit Gully. Pyrites occurred in great abundance, with an assay value of 8 dwt.

The Bruce (G.L. 18 and 19).—This property adjoins the Homeward Bound to the east. Very little work has been done. The country is similar to that of the Homeward Bound.

In 1896 a parcel of 18 tons was crushed for 16¼ oz. of gold.

B. Grassy Gully.

(*a*) *Grassy Gully Mine.*—In 1895 the lease was taken up by Moffat. In January, 1900, it passed into the hands of the Grassy Gully Gold-mining Company, with Mr. P. Durkin as mining manager.

The workings consist of three shafts. The principal one was sunk to 185 feet in June, 1900.

At the 170 feet level a drive nineteen feet long was put in to the south.

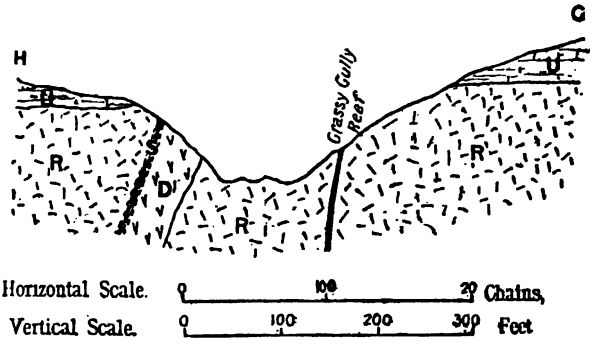
At the 140 feet level a drive twenty-three feet long was also put in to test the country to the south, and at the seventy-eight feet level also a sixty-eight feet long drive was put in (to the south).

These workings are all on the main lode.

No. 2 shaft was sunk on a parallel lode, twenty-five yards to the east of the main lode. This is sixty-six feet in depth. Both "reefs" underlay fifteen feet in every 100 feet to the west. Their strike is almost true north and south.

No. 3 shaft is sixty-seven feet deep. It occurs on the main lode, and has the same underlay as Nos. 1 and 2.

SECTION ON LINE H.G. ON MAP OF GRASSY GULLY GOLD-FIELD.



Reference.

U Upper marine sandstone.
D Dolerite.
S Tuffaceous rocks.
R Rhyolite.

Everything sent up from the process of sinking and driving is passed through the battery. The average width worked is from four to five feet. The formation consists of crushed rhyolite, cemented by silica, and a so-called

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"reef" of quartz traverses the breccia in places along its line of strike, varying in width from two to twelve inches. Gold occurs in the quartz, and also in joints throughout the crushed igneous rock.

The formation is five feet wide at the bottom of the shaft, and averages 11½ dwt. of gold per ton.

Sixty-five per cent. of the gold in the stone is recovered by the battery and vanners.

The battery consists of ten head of stampers, each weighing six hundredweight.

Punched screens (200 holes to the inch) and copper amalgamating plates are in use. The plant was erected in September 17th, 1900.

A Wilfley vanner is in use. According to Mr. P. Durkin, the capacity of this machine is from fifteen to twenty-four tons per day.

A cyanide plant is to be erected, capable of treating 100 tons per day.

It is expected that eighty-five per cent. of the gold in the tailings will be recovered by cyaniding.

Gold Returns.

Since June, 1898, the following gold yields have been reported:—

Tons treated.	oz. gold.	£	s.	d.
54·5	930½	3,744	9	2
49·4	344¾	1,395	17	2
77·6	181¼	724	14	1

For the several months prior to 24th November, 1900, 500 tons were also crushed for a yield of 150 oz. free gold, and 4 tons concentrates, averaging 8 oz. per ton. Total, 182 oz.

Total from June, 1898, to November, 1900, 681½ tons, crushed for 1,638 oz. of gold.

(*b*) *Percival's Claim.*—This is almost in line with the main Grassy Gully Reef. It is, however, said to occur on the No. 2 lode, twenty-five yards east of the main lode.

The shaft is about seventy-five feet deep, and the gold is contained both in quartz and felsite.

No gold returns were obtained from this property.

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APPENDIX I.

Extracts from W. B. Clarke's "Southern Gold-fields," p. 39–40.

. . . . Yalwal Creek consists of three branches, exclusive of Ettrema Creek. As to the auriferous indications of the Yalwal locality, I can only say, from twelve years intimate knowledge of it, that for several years back I considered it to develop more mineral indications than I had seen elsewhere; and that from my first perusals of the descriptions given of the Turon geology, I felt such a strong conviction of its being auriferous, that during the last six months, I have said to many of the Shoalhaven settlers that, ere long, they should find gold much nearer home than they were aware of, and that as soon as they concluded their harvest I would direct them where to find it; and, accordingly, about three weeks ago, I got a gentleman who had some months' experience at the Turon to accompany me to Yalwal, and who, at one part of the locality said that, had I brought him there blindfolded, he would have declared he was on the Turon ranges. But from all I can learn, I have reason to conclude that most of the Yalwal geology and auriferous indications are more assimilated to those of the Braidwood diggings than any other, as most of its rocks consist of coarse red granite, with a good deal of the "conglomerate" in some parts, and interspersed with ranges of red earth, trap rock, and schist without much quartz, except in one of the creeks, where there are considerable rocks of rather a bastard kind. I have often regretted that Mr. Clarke, in his survey of the Shoalhaven, had not his attention directed to Yalwal. . . . . I have just returned from seeing the prospectors; they have found less or more in every place they tried, except one, and rather more of what I conceive to be platina than gold, but some of which they cast away before I arrived there. . . . .

I have, &c.,

A. K. MACKAY,
Commissioner of Crown Lands.

J. R. Hardy, Esq., C. C. Lands.

Extracts from W. B. Clarke, "Southern Gold-fields," pp. 42, 43, 44, 45, 250.

. . . . In that part of Tasmania, and in the country along Yalwal and the Clyde, Silurian slates bearing auriferous quartz veins undoubtedly occur; and I have also detected abundance of auriferous pyrites, not only in the ferruginous schist, but in the quartzose rocks, and even in the granite of Yalwal, and from the decomposition of these auriferous rocks some gold has been set free in the alluvia. But the mass of the country consists of the rocks of the carboniferous formation, all the members of which may be distinguished, from the lower fossiliferous beds between the coast and Yerrirong Creek and sigillaria shales (in the Danjera Creek gullies). . . . . And, whilst poryphyries underlie the fossiliferous beds below the coal and overlie the gold-bearing rocks, the more recent igneous rocks have broken through the carboniferous formation, transmuted and covered it in various parts of the district, appearing in dykes and in overlying and prismatic masses. . . . . I do not doubt, therefore, that there is some gold to be yet found in the ravines, and all along the broken country between the mouth of the Yalwal Creek and the head of Mongarlow River; but it occurs in iron pyrites mechanically united, and in thin quartz veins, which will require the processes of science for the extraction of the metal. The bearing of these remarks on the general capabilities of the Shoalhaven basin will be seen by reference to the Araluen district. . . . .; but, knowing how necessary is the existence of uncovered auriferous rocks, or if covered, covered only by drift of a certain epoch, I could not, even in 1851, have searched the Yalwal country with any respect for my own opinion of it. . . . . I still incline to think that the drift, and the ferruginous schists and quartzose rocks of the Yalwal Peninsula, will not be found very rich in gold. Not till we have got well up on the table-land of Argyle and Murray, have we reason to conclude that an extensive gold-field can exist. No doubt in my mind remains, that though in Tasmania and in the Yalwal Peninsula the true auriferous slates, with the granites of a more recent date, occur beneath the overlying formations; yet in both regions, alluvial gold can only be expected

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in small quantity. Nevertheless, I am of opinion, that between the Sassafras Range and the eastern course of the Shoalhaven, an independent auriferous region does exist, but the value of it can only be determined by long and persevering researches. No sooner, however, do we reach the area of the grey hornblendic or syenitic granites, which are so well developed about Araluen, than gold becomes abundant, diminishing in quantity as we enter the quartziferous schists surrounding it, and becoming very scanty so soon as we come into contact, as in Yalwal Peninsula, with the covering sedimentary deposits of the carboniferous epoch. It has been before stated that the granite of Yalwal is not of that kind; it is rather a coarse pale pinkish rock of loose texture, and having little or no hornblende, with a small amount of mica and bihexahedral crystals of quartz. . . . . It may be mentioned, that on Talwal Creek, which is a Yalwal water, a lode of argentiferous galena was found in 1849, of which an analysis appeared in June of that year. The result gave a very high percentage of silver, but the analyst did not consider it likely to be payable.

Extract from page 250.

In the Yalwal Peninsula, as on Danjera Creek, the same rock† appears associated with Silurian shales and other members of the series, but all of which have been so transmuted by the trappean rocks, as to have become quartzites, or silicified into chalcedony or traversed by thin veins of quartz. This part of the Carboniferous formation has, therefore, undergone the same kind of metamorphosis which distinguishes the lower Palæozoic formation, on which it rests.

† Lower Carboniferous.

DESCRIPTION OF PLATES.

I. Frontispiece. View of Yalwal, looking north.

II. General view of Danjera Creek, looking south from the Pinnacle Claim. Pioneer and Homeward Bound Batteries in middle distance.

III. The Buck Reef. A metamorphosed belt of conglomerate. From the Pinnacle Tunnel.

IV. The Gap. Showing bluffs of upper marine sandstone.

V. Homeward Bound Open Cut. From the Pioneer Open Cut.

VI. Pinnacle and Eclipse Batteries. From the bridge, looking south-west.

VII. Pioneer Battery. From the north.

VIII. Homeward Bound Battery and Cyanide Plant. Looking south-east.

Microphotographs—

IX. Ophitic dolerite.

X. Peculiar Felspar Twinning.

Sydney: William Applegate Gullick, Government Printer.—1901.

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PLATE IX.

OPHITIC DOLERITE.

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PLATE X.

FELSPAR CRYSTAL IN RHYOLITE.

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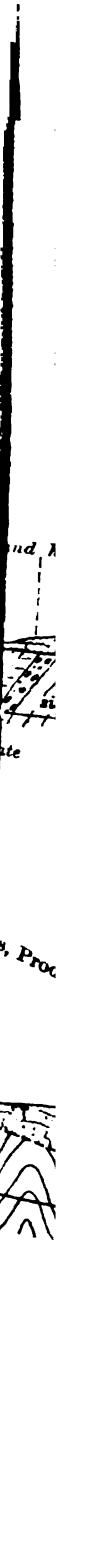

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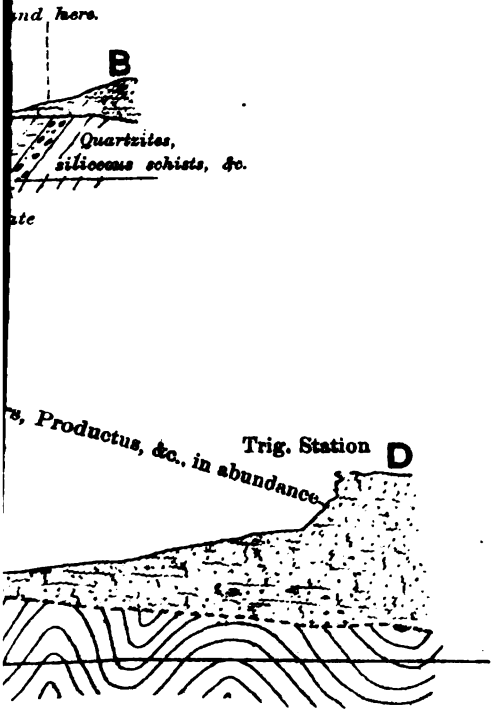

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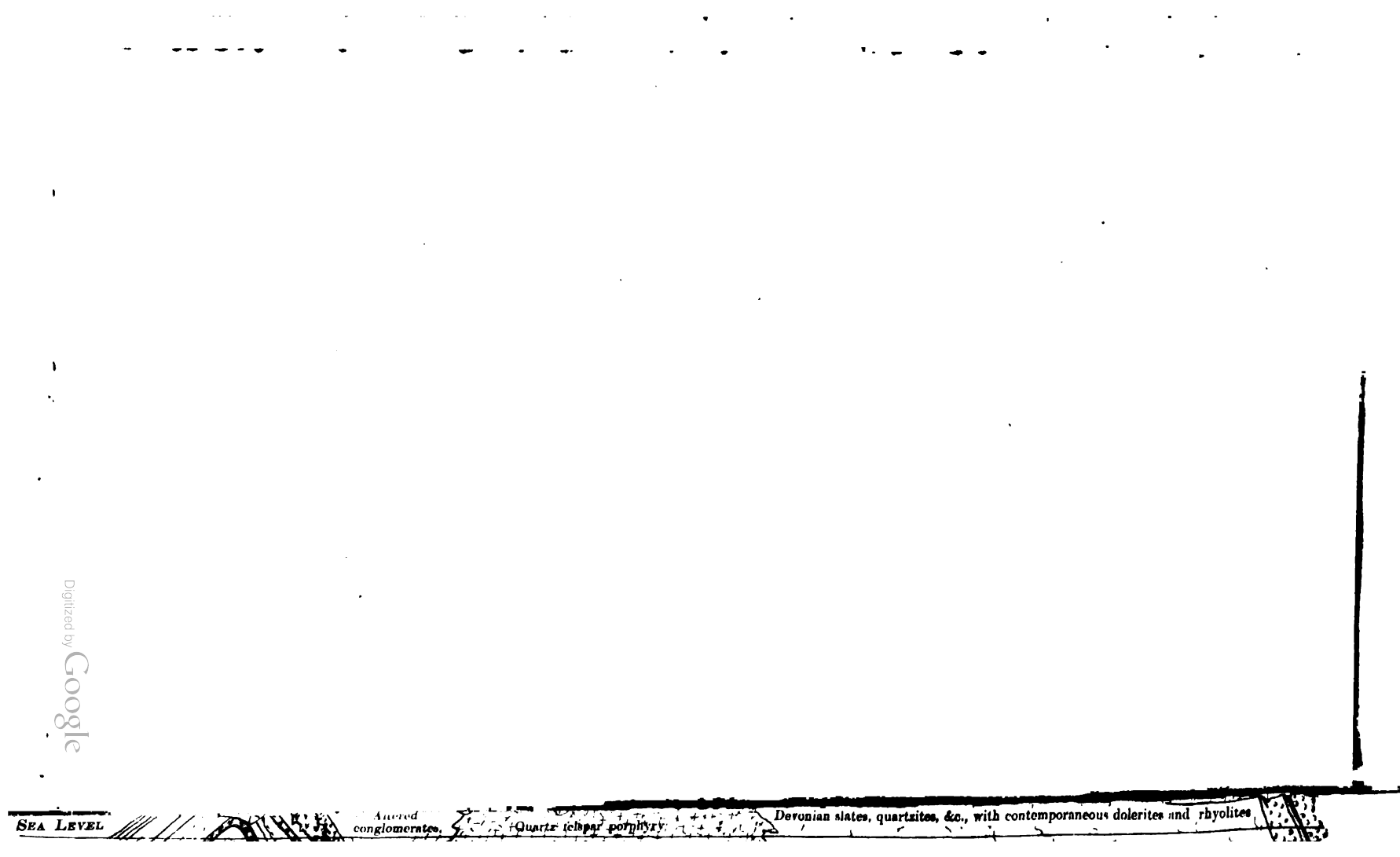
Sea Level
Altered conglomerates.
Quartz felspar porphyry.
Devonian slates, quartzites, &c., with contemporaneous dolerites and rhyolites

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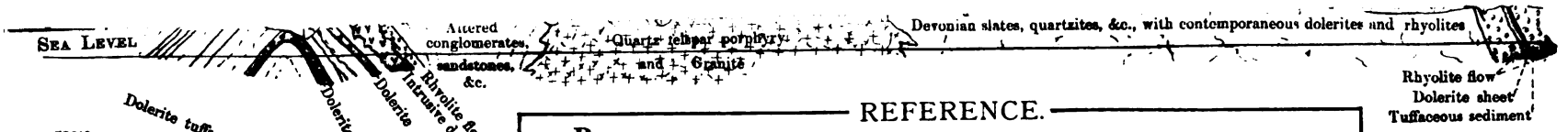

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REFERENCE.

Permo Carboniferous		**Upper Marine** *Sandstones.*
Carboniferous		*Granite, Quartz Felspar Porphyry, Aplite.*
Devonian		*Ophitic dolerites, very vesicular in places, much decomposed, the vesicles being filled with calcite, quartz, &c., and the rock traversed by bands of Serpentine and Epidote.*
Do.		*Banded Rhyolites with tuffs.*
Do.		*Dolerite lavas and sills with sedimentary rocks.*
Do.		*Quartzites, slates, conglomerates, siliceous schists, &c.*

Photo-lithographed by W. A. Gullick, Government Printer, Sydney, N.S.W.

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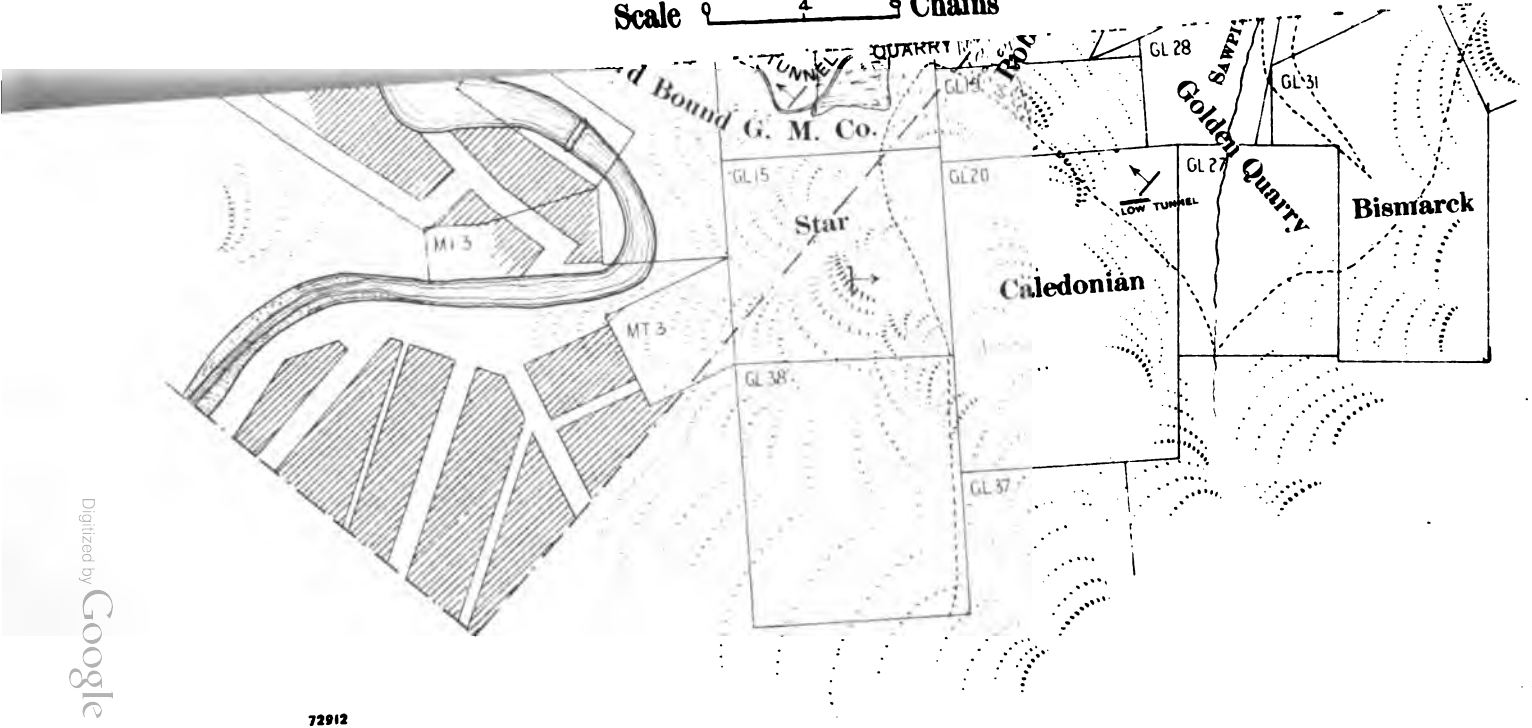
PLAN

Showing Gold Workings, &c., in the

VILLAGE OF YALWAL

Scale 0 4 8 **Chains**



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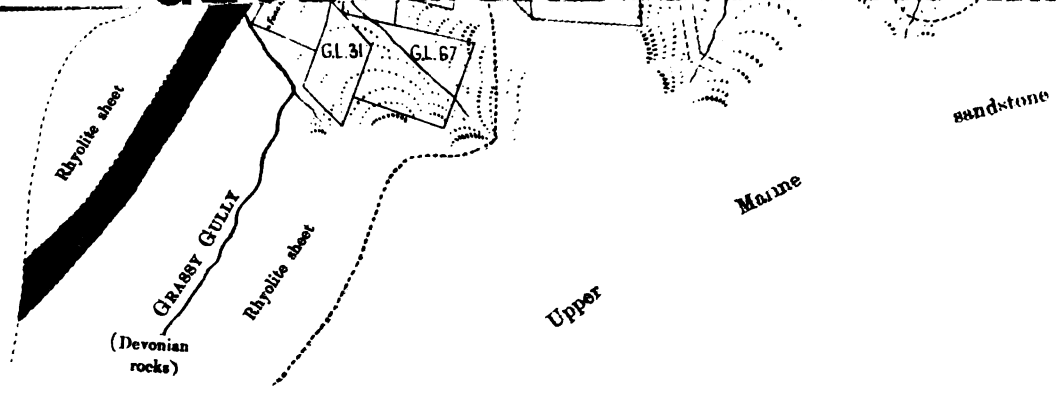
GEOLOGICAL SKETCH MAP



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NEW SOUTH WALES.

DEPARTMENT OF MINES AND AGRICULTURE.

GEOLOGICAL SURVEY.

E. F. PITTMAN, A.R.S.M., Government Geologist.

MINERAL RESOURCES.

No. 10.

REPORT

ON THE

KIANDRA LEAD.

BY

E. C. ANDREWS, B.A.,

GEOLOGICAL SURVEYOR.

1901.

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MISS MARIE ROMINGER
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MRS. MARK COVILL

FEB 25 1937

Geological Survey of New South Wales,
Department of Mines and Agriculture.
Sydney, 17th July, 1901.

Sir,

I have the honour to submit for publication No. 10 of the Mineral Resources Series, entitled, "Report on the Kiandra Lead," by E. C. Andrews, B.A., Geological Surveyor.

The gold deposits of Kiandra were discovered in 1859, and quickly attracted about 15,000 persons to the locality; but the rich shallow alluvials were soon worked out, and the greater part of the population then departed.

The deep Tertiary lead, from which the shallow gold deposits had been shed, was known to occur in close proximity to the first settlement, and its exposed edges, on the slopes of the hills, received some attention from the pioneer miners, and have been worked in a desultory manner by hydraulic sluicing almost ever since; but it is not practicable to work the central portions of the lead by that process, because of the thick overburden, consisting of beds of lignite and clay, and a capping of basalt, amounting to several hundred feet in the aggregate. Some parts of the deep lead have also been exploited by tunnelling. It is evident, however, that a considerable amount of capital is required to systematically work these deposits, which are of great length and width, have a rather irregular bottom, and are troubled with a considerable quantity of water.

With the object, therefore, of attracting attention to this important but comparatively neglected goldfield, it was thought advisable to have a geological survey of it made, and the course of the lead defined. One of the results of Mr. Andrews' work has been to show that there are two distinct Tertiary river deposits, which he has named respectively the Kiandra Lead and the Round Mountain Lead.

I have the honour to be,
Sir,
Your obedient servant,
EDWARD F. PITTMAN,
Government Geologist.

The Under Secretary for Mines and Agriculture.

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SYNOPSIS OF CONTENTS.

PAGE.

1. Synopsis of Contents 4
2. Introduction 5
3. History of Field; Discovery of payable Gold about December, 1859 7
4. Previous References to the Kiandra Lead 7
5. Physiography; Topography; Meteorology; Vegetation 11
6. Geology:—
   - A. General Geology 13
   - B. Sedimentary Rocks 15
   - C. Eruptive Rocks 17
7. The Leads:—
   - A. The Kiandra Lead:—
     - (1) Extent 19
     - (2) Argument in favour of lead against lake formation 20
     - (3) Description of claims and auriferous contents of lead 23
       (*a*) The Empress Claim and neighbourhood. (*b*) The South Bloomfield. (*c*) The North Bloomfield. (*d*) Basalt Claim and Tunnel. (*e*) Northern portion of Township Hill. (*f*) Homeward Bound, Cornishmen's, Pattinson, and Winckler's Claims. (*g*) Robyn's Tunnel, the Giandarra, All Nations. (*h*) The Six-mile.
   - B. The Round Mountain Lead:—
     - (1) Extent 30
     - (2) Description of claims 30
       (*a*) The Fifteen-mile. (*b*) Eight-mile. (*c*) New Meragle.
8. The Kiandra Reefs 26
9. Methods of working the Kiandra Lead 27
10. Township Hill 29
11. Description of Plates 32

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INTRODUCTION.

THE great extent of basalt with underlying drift at Kiandra has long been known to the mining community. Many attempts have been made to prove the auriferous nature of the wash, but they have, for the most part, been conducted in a haphazard fashion.

The following report, with plans, sections, and photographs, has been prepared with the object of showing the extent, probable nature, and auriferous character of the lead.

I desire here to cordially thank Mr. A. R. Winckler for much valuable information and assistance in the field; also Mr. J. M. Lette, Mr. A. Reeckmann, Mr. C. L. V. Jackson, B.E., Mr. Eastwood, Mr. Hetherington, and Mr. C. Burgess, for their kindness in showing me various points of interest in the locality, and in furnishing any information at their disposal concerning the lead.

The maps and sections have been prepared by Mr. O. Trickett, L.S. I desire also to thank Mr. C. E. Murton, Field Assistant, for his cordial co-operation in the work.

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REPORT ON THE KIANDRA LEAD.

HISTORY.

KIANDRA (a corruption of the word Giandarra) Gold-field broke out in November, 1859, with the discovery of payable gold in Pollock's Gully by Gillon, Hayes, and Grice.

The first gold had been found, however, in Bullock Head Creek by the Pollock Bros., who were accustomed to bring sheep from the Murray to Kiandra in summer, and, while the flocks were feeding, to spend most of their time in prospecting.

The Pollocks on their return reported the find in Tumberumba. In December, 1859, and January, 1860, a great rush to Kiandra set in.

In February and March it was estimated that 15,000 men were on the field.

The country to the south being exceedingly rough, a surveyor named Ligar devised a route for the Victorian miners by way of the Upper Murray, coming into Kiandra through Happy Jack. This was known as Ligar's Route.

As the diggers swarmed along this and other routes they prospected the area in the neighbourhood of Table Top Mountain and the Four Mile.

Towards the end of January, 1860, the Four Mile rush took place, and about 1,000 miners were soon employed on the spot, many of them making small fortunes.

The Nine Mile also broke out at this time, and kept another 1,000 people employed. The finds here were almost phenomenal.

A week after the Nine Mile rush took place exceedingly rich prospects were found at the Tumut River, on Benjamin's Flat, near the intaking of Scott's Gully and Nine Mile Creek.

The rich properties in the localities just mentioned were almost always confined to small watercourses leading up to the basalt-capped hills, which stretch for a distance of ten miles both north and south of Kiandra.

The following newspaper extracts explain the state of affairs in Kiandra during February, March, and April, 1860:—

"One party consisting of four men got 120 oz. in the week, another party of three were getting 20 oz. per day. Several large nuggets found—6 lb., 12 lb., 14 lb. Another party getting 1 lb. weight gold per diem. The gold procured is coarse and scaly, and large specimens blended with quartz and all much waterworn."—(*Sydney Morning Herald*, 23rd February, 1860.)

"One party before dinner got 176 oz., and another got one lump weighing 19 lb."—(*Sydney Morning Herald*, 25th February, 1860.)

"Five hundred ounces of gold are being got daily. In one dish yesterday they got 21 dwt., and to-day they got 7 lb. weight of gold. One of the party told me they had averaged 20 oz. per day from the beginning. I heard of another party of twelve men getting £73 worth of gold for last week's work."—(*Sydney Morning Herald*, 2nd March, 1860.)

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"I saw 80 oz. of gold washed out of one claim in the day's work, and several are turning out 50 oz. per day. These are the best claims from the Surface Hill in the middle of the plains to the edge of the plains where the river begins. The Commissioner has taken with him to Sydney a nugget weighing 48 oz., and another weighing 20 oz., besides a large quantity of coarse gold. The diggers wash out the boxes twice a day. An ordinary yield of gold is from 60 to 70 oz. before dinner and from 30 to 40 oz. at night. Elliot and party of four washed out 80 oz. last week from surface diggings. D. Scully and party have averaged 21 oz. a day for five or six weeks; so have others, some claims have turned out as much as 100 oz. of gold per day, and many as much as 40 and 50."—(*Sydney Morning Herald*, 7th March, 1860.)

"Over an area of half a square mile the workings have proved as rich as any ever discovered in Victoria or California. But, singular to say, beyond this particular spot on the river the precious metal is obtainable only in very small quantities indeed. * * * The Commissioner computes the daily average yield of Kiandra diggings at 500 oz. to a population of 2,500 or 3,000."—(*Sydney Morning Herald*, 20th March, 1860.)

"Many robberies—stickings up. Thieves get their heads close shaved or hair cut. * * * The escort with eleven mounted troopers left Kiandra on Monday with 7,469 oz. It was believed there was fully 5,000 oz. in the hands of the miners, independent of the amount brought down by the escort."—(*Sydney Morning Herald*, 5th April, 1860.)

The field was at first compared with Ballarat and Bendigo, and it was computed that after the winter of 1860 there would be 150,000 men in the locality.

Previously to the rush some exceptionally severe winters had been placed on record, the knowledge of which filled the prospectors with a wholesome dread of the approaching Alpine conditions.

For instance, Dr. Gibson, in the year 1839, had visited the locality, and, struck with the abundance of rich pasture, had erected a stockyard and brought up cattle in the fall of the year. The winter set in, with the usual accompaniment of heavy snow, and all the cattle perished.

A prospecting party on Township Hill had also come on the skeletons of bullocks hanging in the tops of the snow-gums, fully twenty feet from the ground, near the summit of the hill and a considerable distance from any watercourse. It was evident from this that the trees had been covered with snow, to enable the animals to browse off the top twigs.

For these reasons many men kept off the field until the cold weather of 1860 should pass, but the reports were so discouraging at the close of that season that the population did not increase to the extent anticipated. The maximum population was reached about March, when between 10,000 and 15,000 people were on the field. In April, 10,000 were living in the locality. In August, 4,000 were occupied at Kiandra, 200 at the Four Mile, and 400 at the Nine Mile.

The field was patchy, gold being extremely rich in certain spots, barren ground existing within a few yards of the good yields. Surface Hill and Whipstick Gully yielded many large nuggets and specimens, as may be seen by consulting the columns of the *Sydney Morning Herald* for the months of February, March, April, and May of 1860.

One was found by O'Donnell and Party on the east side of Surface Hill Reef, and alongside of the same. This on crushing yielded 28 lb. weight of gold.

On Whipstick Flat another specimen was unearthed by Iles and Party, 27 lb. weight of gold being obtained by crushing.

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Many 30 and 40 oz. weight nuggets occurred in the river, and all well rounded.

The gold escort was not established for several months after the start of the field, and most of the precious metal is supposed to have been taken away during the few weeks following on its discovery, and of this no record has been kept. Nevertheless up till 30th June, 1860, the escort had taken charge of 42,000 oz.*

Shortly after the commencement of gold-mining operations at Kiandra it was found that old river drift existed in large quantities under the north and south extension of the basalt. This fact was determined by tracing the gold up the watercourses leading to the basalt cappings of the hills. In this way the Homeward Bound, Cornishmen's, Pattinson and Winckler's, the North and South Bloomfield, and Empress Claims were discovered and opened up.

The Homeward Bound was traced up from Bullock Head Creek by three prospectors, who lighted on an auriferous pothole in the old river channel under the basalt. The gold occurred in a stiff clay matrix. A puddling machine was erected here in March or April, 1860. The prospects from the pothole were good, £1 10s. to £2 a day per man being obtained when water was plentiful. The question of water was at first a great drawback in sluicing. This difficulty was overcome to a great extent in the following December, when the system of constructing races was commenced. The first of these was cut from the Three Mile to the Homeward Bound. With this the pothole was attacked vigorously. It proved to be remarkably rich, 1,000 oz. of gold being obtained.

The Cornishmen's Claim was discovered about April or May, 1860. Half an ounce a day per man was obtained by utilising a little water brought from the top of New Chum Hill.

A miner named "Joe the Frenchman" afterwards procured the claim, and, in the course of a year or two, extracted £800 worth of gold from the base of the drift.

Four Cornishmen then bought the foreigner out. Very good results were obtained by this party.

In the meantime tunnelling had been resorted to in the vicinity of the last two mentioned claims in the hope of thus winning the gold.

The first drive was started under Pattinson and Winckler's sluicing claim by Cameron and Party, who discovered gold in their workings early in 1861.

Colquhoun and Party had another claim alongside, and came on good gold also in 1861.

Drummond and Party drove along the centre of the channel in the same year. From their tunnel the returns are said to have averaged 14 dwt. per superficial fathom. These old workings have since been broken up by hydraulic sluicing in Pattinson and Winckler's Claim.

The Six Mile was worked in the latter end of 1860, £10 a man per week being obtained in the wet season.

At the Empress (Nine Mile) actual sluicing operations commenced in 1860, and were carried on intermittently till 1882.

In 1866 or 1867 the Emperor Company put in a tunnel between the Homeward Bound and Cornishmen's Claims. This helped to establish the width of the channel.

About the end of 1878 these sluicing claims were floated into what was known as the Kiandra Gold-mining Company. In 1882 the Three Mile dam was constructed and connected with the claims by means of a large headrace, 130 feet above the base of the wash.

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* Rev. W. B. Clarke. Southern Gold-fields, page 267.

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Hydraulic sluicing was started in these claims in 1883.* One nozzle was at first employed, but subsequently an additional one was brought into play.

The Cornishmen's, and Pattinson and Winckler's Claims were afterwards sluiced by hydraulic methods.

In the year 1882 or 1883 the Kiandra G.M. Company introduced hydraulic sluicing at the Nine Mile (Empress) Claim.

A scheme for conveying water to the nozzles from the Doubtful Creek, some 30 miles distant, was considered by Mr. H. B. Sullivan, L.S.,† who took the necessary levels. It was found that two or three large gullies existed across which the water would have to be siphoned.

When the overburden at the Empress Claim reached a thickness of 150 to 160 feet sluicing was abandoned in favour of tunnelling.

At the Four Mile two sluicing claims were taken up, viz., the North and South Bloomfields. Of these, the former was started in 1862, and the latter in 1883 or 1884.

The Giandarra, Robyn's Tunnel, and All Nations' Claims, some two miles to the north of Kiandra, have all been started within the last few years.

The claims just referred to are all on the line of what is known as the Kiandra Lead.

Other sluicing claims have been opened up to the west of the Kiandra Lead; among these may be mentioned the Fifteen Mile Claim, started in 1875 by Hugh O'Connor.

Three miles thence towards the Tumut River and on the Fifteen Mile Creek the sluicing claims known as the Golden Crown and the Phœnix were started in 1883, the former being treated by nozzles.

The Eight Mile Sluicing claim, also belonging to the Fifteen Mile Sluicing Company, was started in 1883.

In all these claims great quantities of drift have been sluiced away from beneath the basalt; but their gold yields were not nearly of so profitable a nature as those derived from the Kiandra Lead.

The Kiandra Reefs.—The finding of the Jackass Flat (1860), Surface Hill (1860), Three Mile (1864), and Charcoal Reefs caused great excitement from time to time. Although the Jackass Flat and Three Mile Reefs paid handsomely at first, they were found to become practically barren at a short distance from the surface.

At present gold-mining operations at Kiandra are confined to the dredging of ground along the Eucumbene River by the Kiandra Gold-dredging Company; to tunnelling at the Empress, Giandarra, and the Six Mile; and to fossicking along Nine Mile Creek, Scott's Gully, Four Mile Creek, the Eucumbene River, Bullock Head Creek, Six Mile Creek, and Racecourse Creek.

The Kiandra bucket dredge (Plate I), working in ground turned over several times already by the diggers, wins from 30 to 35 oz. of gold per week. The revolving screen belonging to this dredge has been taken out, and a sluice-box substituted.

A considerable area has also been taken up along the Tantangara Creek for dredging purposes.

PREVIOUS REFERENCES TO THE KIANDRA LEAD.

C. S. Wilkinson.—Ann. Rept. Dept. Mines for 1880 (1881), pp. 239–242.

H. B. Sullivan.—Rept. on water supply for Kiandra Gold-field. *Ibid.* for 1880 (1881), pp. 265, 266.

W. H. J. Slee.—*Ibid.* for 1885 (1886), pp. 107, 108. *Ibid.*, 1898 (1899), pp. 94, 95.

* Introduced by J. M. Lette, Esq. † Ann. Rept. Dept. Mines for 1880, pp. 265, 266.

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KIANDRA BUCKET DREDGE.

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L. H. G. Young.—Report on Kiandra Gold-field, and water supply for the same. *Ibid.* for 1880 (1881), pp. 253–258.

W. Anderson.—Report on Kiandra Gold-field. *Ibid.* for 1886 (1887), pp. 165, 166.

J. R. M. Robertson.—Kiandra Gold-mining Company (Limited). Report on Kiandra sluicing claims, New Chum Hill (Fol., Sydney, 1887).

W. C. Roberts.—Report on Victoria Mines, Kiandra. Ann. Rept. Dept. Mines for 1882 (1883), p. 72.

W. D. Bailey.—*Ibid.*, pp. 71, 72.

These two reports sum up concisely all information concerning capacities of dams, lengths of races, &c., employed at Kiandra.

Various Wardens' reports are to be found in the Annual Reports of the Department of Mines, from 1875 (1876) to the present year.

PHYSIOGRAPHY.

Topography.

Kiandra is situated on a high table-land determined as to its general features by the main Snowy Mountain Range, which, disposing itself in pointed-ellipse form in the vicinity of the township, so as to embrace it between its eastern and western curves, passes through to the south by way of Table Top Mountain. (Pl. II.)

The town is some 4,600 feet above sea-level, and lies 58 miles south-east of Tumut, 51 miles west-north-west of Cooma, and 40 miles north of Kosciusko.

The table-land is dotted over with numerous hills composed of tuffs, slate and granite, rising to heights of 1,000 to 2,000 feet above the general level. Among these peaks may be mentioned the Big Bogong (6,753 feet), Table Top Mountain (5,850 feet), the Round Mountain, Alpine Hill, Governor's Hill (5,723 feet), Yarrangobilly Peaks, and Peppercorn.

The main range, in the vicinity of the town, is typically flat-topped, a feature due to its basaltic capping. Through Governor's Hill (Kiandra Trigonometrical Station) the range sweeps round to the north-west by way of the Six Mile (where the basalt starts), Gooandra Trigonometrical Station, and Bullock Hill (Pl. II); thence, turning sharply on itself, it passes through the Three Mile, leaving the town to the immediate east; through Township Hill, Nine Mile, Table Top Mountain (where the basalt ceases), the Bull's Peak, and Mt. Kosciusko.

On each side of the plateau profound gorges occur, expressions of the amount of material removed by such streams as the Tumut during the process of excavating their present channels.

The Snowy Range forms the watershed for the local streams. The chief water systems are those of the Snowy and Murrumbidgee Rivers.

Inside the sharp curve formed by the main range at Bullock Hill the Eucumbene gathers together its head waters, and flowing towards the south joins the parent stream (the Snowy River) at Jinderboin.

The Murrumbidgee River has, as its chief feeders in this district, the Tumut and the Goodradigbee.

The main stream rises in a mountain known as Peppercorn. Here also the Goodradigbee has its source, flowing many miles before uniting with the trunk stream.

The Tumut takes its rise in the neighbourhood of the Big Bogong and the Bull's Peak, and carves its way through the mountain blocks to the Murrumbidgee in a perfect labyrinth of gorges, some as much as 3,600 feet below the general level of the plateau.

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Besides the basalt mass which forms the summit of the Snowy Range in the neighbourhood of Kiandra another and larger one apparently has its source, or one of them, in the vicinity of the Round Mountain. From this as a centre it flows in the direction of the Tumut River, through the Fifteen-mile and Eight-mile claims, then across the Tumut by way of New Meragle, and thence in the direction of Batlow.

These basalt flows are further interesting by reason of the comparisons which may be instituted by a study of them between present and late tertiary topographical conditions.

(1.) From the Nine Mile to the Twelve Mile, a distance of 20 miles, the Kiandra lead shows a fall of 785 feet.

This then indicates the direction of the old stream, viz., from south to north.

The present Encumbene River rises near the Six Mile, and flows thence past the Nine Mile. Thus the two streams ran in opposite directions.

The Round Mountain lead has a fall in the direction of the Fifteen Mile, Eight Mile, and New Meragle. Its course is thus fairly parallel for miles with that of the present Tumut River.

(2.) The basalt flowed along the old river-beds, thus occupying the lowest portions of the country at that period.

(3.) The Tumut has cut very deep ravines through these basalt caps and the underlying rocks.

Near the Fifteen Mile Claim the Tumut gorge is 2,500 feet deep; the basalt has been trenched across, and occupies at present the highest portion of the land in the neighbourhood.

At New Meragle wash with basaltic covering has been found near the edge of the Tumut gorge and 2,200 feet above the stream, while the Tumut River at its junction with the Yarrangobilly is 3,600 feet below the basalt cap forming its eastern bank.

From (2.) and (3.) we see how potent have been the forces of erosion since the basalt outburst; for since the deep leads represent the lowest levels reached in Tertiary times, and seeing that the basalt occupied these lowest sites, and also that the present rivers have cut their way through the basalt cappings, it is clear that all gorges in the locality below these old levels must post date the period of basaltic eruption.

(4.) The leads show a great quantity of alluvial deposits, amounting to a thickness of 150 feet and a width exceeding 10 chains, while the present river beds of the locality are small and rapid with scanty deposits of wash.

In the neighbourhood of the Nine Mile even to day the leads are separated by a ridge of rock much more elevated even than the Nine Mile claim. Taking into consideration the enormous amount of denudation effected since the existence of the leads as water systems, the great quantities of gravel and lignite contained in the leads themselves, it is only natural to surmise that a little while before the basaltic outbursts two large streams flowed in the neighbourhood of Kiandra, one in a northerly, the other in a north-westerly direction; that they were separated in the vicinity of Kiandra and the Nine Mile by a high ridge; that they have their sources in the mountains to the south, which were much more conspicuous than at present, besides being perenially snow-capped during a certain period, and that at various stages of the river history the vegetation along the banks formed growths comparable in luxuriance with those seen in the "brushes" of the present coastal areas.

Meteorology.

Kiandra district has no well-defined seasons. The summer weather is generally mild and pleasant, but heavy frosts and snowstorms have been recorded in December and January. One storm is mentioned during which

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KIANDRA TOWNSHIP AND EUCUMBENE RIVER.

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3 feet of snow fell on the 26th December. The average annual temperature is 44·5 degrees, the maximum officially recorded shade temperature is 85°, and the minimum—20° (52 degrees of frost) in August, 1882.

The rainfall is 63·78 inches per annum, and the town, in severe winters, is almost buried beneath snowdrifts.

The prevailing wind is from the north-west.

Vegetation.

The mountain ash attains a prodigious height in the deep gullies. At the bases of these gorges messmate and white gum abound.

The hardy snowgum is the only timber that can withstand the wind and snow in exposed situations at altitudes exceeding 5,000 feet. On the windward sides of the hills these trees have a regular network of branches, twisted into all manners of curves, and possessed of exceeding toughness so as to withstand the great snow pressures they are subjected to. In these shelterless spots also the snow timber permanently leans to the south-east, owing to the force of the prevalent north-west wind.

At altitudes exceeding 6,000 feet no trees will grow.

Heaths, peaty growths, and stunted vegetation are exceedingly common. On the gathering grounds of the streams a curious phenomenon occurs, the surface over large areas appearing as if stripped in places for turf-getting. These bare patches are always narrow as compared with their length, being bluntly crescentic in shape. A frequent width is 2 feet with a length of 10 feet. They occur as depressions, some 6 to 8 inches in depth, and are almost equal in total area to their well-grassed surroundings. They are always arranged normally to the direction of flow of the water, and occur only on spots with little or no fall. The ground around is remarkably well grassed, being quite springy when walked upon.

They form a most instructive lesson in the compromises effected between animate and inanimate forces in the adjustments of their respective boundaries.

At the points on the hillsides where the water issues from beneath the basalt capping thick spongy masses of vegetation collect, sometimes as much as 3 and 4 feet in thickness.

GEOLOGY.

1. General Geology of District.

The geological formations in the vicinity of Kiandra are extremely interesting, consisting as they do of well-marked claystones, breccias, conglomerates, sandstones, quartzites, shales, fossiliferous limestones, hard siliceous and soft fissile slates, tuffs, and felsites (?) intruded by sills of syenitic-diorite, norite bosses, basic andesites, quartz-felspar porphyries, gneisses, and granites.

Of the rocks observed, the oldest occur in the neighbourhood of Lobb's Hole Copper-mines, and consist of siliceous claystones, breccias, conglomerates, sandstones, and quartzites. These, the lowest members of the series, are in the main suggestive of very shallow marine conditions. The finer-grained sandstones and the quartzites further emphasise this point by reason of well-preserved ripple marks and annelid (?) tracks found in them.

The upper 100 feet of these rocks, by reason of superior hardness, outcrop boldly on the hillsides (Plate III), sweeping up or down the ravine slopes according to the prevailing dip. These constitute such a marked feature in the landscape as to be known as "The Walls."

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Above these large lenticular patches of limestone were laid down, containing abundant fossil remains.

To these succeeded great masses of shales and slates, indicative of deeper sea conditions.

These in turn gave place to great accumulations of fine and coarse tuffs of an andesitic character. Rocks here occur possessing markings similar to the flow-contortion structure seen in many felsites, as well as small bands of tuffaceous slates.

Slates and sandstones, since silicified in great measure to quartzites, mark a still later period of sedimentation.

The younger members of the series, *e.g.*, the tuffs, quartzites, and slates, appear to have been intruded by rocks showing affinities with both quartz-syenites and quartz-diorites in the form of a large sill with smaller attendant dykes.

In Racecourse Creek another type of rock, possibly also a syenite, occurs in the form of bosses and sills. This, as also the syenitic-diorite, appears to have partaken in all the dynamic metamorphism of the district.

Several basic andesite dykes occur in the neighbourhood of the dioritic rock, and are doubtless associated with it. These rocks are also extremely altered.

Small norite bosses appear to have made their appearance next.

Equally small granite bosses occur, which weather out into very similar forms. Both are scattered capriciously over the field, and appear to be closely associated with each other, and probably do not differ much in age.

In Carboniferous (?) times the great districtal disturbance took place in the form of huge granitic and gneissic intrusions. This is the age of so much of the granite and granitite of Eastern Australia.

Most probably the whole of the Upper Silurian strata of the district was influenced by earth movements, and became possessed of a fairly high angle of dip at a period ante-dating the granitic intrusions. These latter, however, were on a magnificent scale, and there is little doubt that in the Kiandra district the crumpling of the rocks observable along the Yarrangobilly River was determined mostly under the influences of these acid bosses.

After the close of the Palæozoic period geological influences were mostly confined to the work of disintegration and erosion. The mountains were planed down, the granite massifs which had cooled at great depths were bared, and themselves fashioned into high peaks.

In middle and late Tertiary times the rivers of the district were larger and flowed in the opposite direction to the present course of the Eucumbene River.

A long period appears to have been occupied in the formation of huge deposits of river material. Subsequently different climatic conditions obtained. Luxuriant growths of vegetation, attended doubtless by much milder temperatures and abundant rainfalls, clothed the banks of the ancient rivers. These formed the thick masses of carbonaceous material which form such a prominent feature of the "lead" sections.

After the deposition of the lignite, sand, clay, and fine river-wash were deposited in thin beds, to be followed by other beds of lignite.

After several alternations of stony and carbonaceous layers, a great basaltic outburst took place, probably in late Tertiary times. From different centres, such as Table Top Mountain, Round Mountain, Pig Gully Hill, &c., basalt was poured out in great streams, filling up the old river-beds for many miles. The diverting of the streams into other channels by this volcanic display has been discussed under the head of physiography, as also the probable amount of material removed by atmospheric agencies since that time.

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"THE WALLS," LOBB'S HOLE.

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2. Sedimentary Rocks.

(*a.*) *Recent and Pleistocene—Shallow alluvial deposits—Calcareous deposits in watercourses.*

To those belong the present shallow "placers" of the district, and the masses of travertine encrusting the strata underlying the bedded limestone at Lobb's Hole.

At this locality a large mass of limestone occurs, immediately overlying the hard quartzite formation known as "The Walls." These occur as almost sheer faces, varying in height from 40 to 250 feet. Near the Copper Mines masses of travertine encrust "The Walls" at the heads of the gullies, and have in one or two cases the appearance of limestone inliers. Their origin is instructive. On the top of "The Walls" a species of tea-tree scrub flourishes in the soft tufa brought down the watercourses. Alongside of these also thick masses of mossy growths flourish in the tufa. The calcareous material is deposited on these vegetable growths, and quickly covers them up, but the lowly vegetation grows upward and outward, so that as the lower portions are wholly enclosed by the tufa the upper part is still vigorous. Thus the secondary calcareous material has a tendency to advance in an upward and outward direction. The tea-tree masses also flourish on the perpendicular face of the tufa, and are being continually buried in the calcareous mass. The tufa thus formed is extremely light and porous, but as the mass thickens the vegetable constituent perishes, and percolating waters consolidate the whole into compact limestone and calcite. In one place this secondary growth has advanced fully 70 to 100 feet in front of the quartzite precipice, and is itself a precipice fully 100 feet high and 200 feet in width. The old part in contact with the base is of calcite, eaten into large caverns containing many beautiful stalactitic growths, while the perpendicular face of the travertine or tufa is covered with tea-tree and mossy mass. All the tea-tree branches and roots have a thick coating of tufa.

(*b.*) *Tertiary.*

The Kiandra Lead—The Round Mountain Lead.

The Kiandra Lead.—The deposits occurring in this lead consist of the following, with local modifications:—

1. Auriferous wash.
2. Sand and clay.
3. Iron pyrites.
4. Earthy lignite.
5. Clay and sand.
6. Earthy lignite.
7. Sand and clay.
8. Earthy lignite.

The total thickness of the beds is about 150 feet. Abundant traces of leaves are contained in the layers of lignite. Perfect specimens are rarely procured, owing to the softness of the matrix.

The Round Mountain Lead.—The succession of beds here has been discussed elsewhere in the report, as also the occurrence of leaves in an excellent state of preservation.

C.—*Upper Silurian* (?).

The strata of this Palæozoic age fall naturally into five divisions:—

(1.) A lower series, consisting of claystones, breccias, conglomerates, sandstones, and quartzites, the upper beds of which form "The Walls." (Plate III.)

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Of these, the breccias and conglomerates deserve special mention. They are lenticular in character, attaining enormous local developments. At the Copper-mines the breccia forms a thin sheet, containing angular fragments of quartzite about the size of a walnut. A mile to the east it makes into a much thicker bed, the dip of which corresponds with that of the mountain it constitutes in part. The quartzite fragments are large, varying from 6 to 18 inches in diameter, and are set in an impure quartzite cement. This cement weathers more rapidly than the enclosed fragments, and the weathered surface of the breccia then has the appearance of a rough talus slope. The fragments, however, when struck with a hammer, are found to be *in situ*.

The conglomerates and grits are closely connected with the breccias, and form in the Yarrangobilly River cañon cliffs as much as 100 feet in height. The bulk of the strata is composed of well-rounded quartz pebbles, set in an insignificant amount of cementing sandstone. The pebbles vary in diameter from 1 to 12 inches. They rest on fissile slates and quartzites.

The overlying sandstones are indurated, and the quartzites very fine in texture.

(2.) *The limestones* are lenticular in character. Two deposits occur, one at Yarrangobilly, the other at Lobb's Hole. Their periods of deposition are probably not far removed, although the folding to which the country has been subjected would necessitate detailed examination to decide this point. The principal difficulty lies in the great variations in the dips, and the very local development of rock characteristics, conglomerates giving place to sandstones and slates within very short distances.

The following fossils, obtained from the Lobb's Hole limestone, have been identified by Mr. W. S. Dun, Palæontologist to the Survey:—

Spirifera Yassensis. *De Koninck* (abundant).
„ multiplicatus. „
Pentamerus Knightii. *Sowerby*.
Rhynchonella (Uncinulus) Wilsoni. *Sowerby*.
Chonetes striatella. *Dalman*.
Athyris, or Meristella.
Modiomorpha (?).
Fragment of a rugose coral, Amplexus (?).
Orthoceras.

Mr. Etheridge has also determined from these beds—

Spirifera latisinuatus. *De Kon*.
Rhynchonella cuboides. *Sowerby*.

The latter most probably is the form listed above as *R. Wilsoni*.

A species of *Paracyclas* has also been collected from these beds by Mr. Warden Love.

At Yarrangobilly the predominant brachiopod is *Pentamerus Knightii*, represented at Lobb's Hole by a single fragment.

Associated with *Pentamerus Knightii* in these beds are found (as determined by Mr. Etheridge in 1894)—

Bellerophon (two species).
Euomphalus, or Oriostoma.
Ptycomphalina.
Cyclonema.
Murchisonia (Hormotoma, or Cœlocaulus).
Pleurotomaria (Mourlonia, or Ptycomphalina).
Orthodesma (?), and a large indeterminable bivalve.

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(3.) The slates have a higher and more uniform dip than the lower conglomerates and breccias. They are very fissile, "creeping" structure is of common occurrence; decomposition has set in, turning the slates to a green colour, and silicification is very pronounced.

Most of the reefs occur in these strata. The prevailing strike is N. 15° E.

(4.) *The Tuffs.*—These form the majority of the rocks about Kiandra township. They occur as bands of coarse green rocks alternating with fine-grained grey varieties having a felsitic appearance. Although conforming in the main to the strike of the country, they present decided local variations, the strike of the beds in these cases being at times at right angles to the prevailing trend of the country. The tuffs at times are so compact as to be almost indistinguishable from igneous rocks. They have been classed hitherto as diorites. In the finer-grained varieties the fissile structure so pronounced in slates are characteristically absent.

(5.) The quartzites and siliceous slates to the east of the tuffs possess the same general strike as the fissile slates to the west. They are extensively developed about Sawyer's and Governor's Hills. No traces of fossils have been discovered.

C.—*Eruptive Rocks.*

1. *The Syenitic-diorites.*—These occur mostly in the form of a huge dyke or sill, more than 6 miles in length, and conforming generally to the strike of the associated slates and tuffs. The map shows its approximate boundaries only. In several places it is reduced to two or three narrow dykes, while at the Eucumbene River and at the Four-mile Creek it broadens considerably. Its probable north and south extensions beyond the limits shown on the accompanying map were not followed.

The rock weathers out into ragged forms, and not after the typical manner of coarsely-grained plutonic rocks. Its age appears to considerably ante-date all other intrusive igneous rocks of the locality. The component minerals have been much decomposed; the forces of dynamic metamorphism are very evident, and slickensided epidote is a common constituent.

Numerous syenitic dykes attend the main line, especially on Sawyer's Hill, near the intersection of the Cooma-Kiandra road with the Eucumbene River.

Several very basic andesitic dykes appear to be associated with this syenitic rock. They are composed of uralitised augite phenocrysts set in a fine matrix. They appear to have been much altered.

2. *The Norites.*—These occur as very small rounded bosses, weathering out into large spheroidal blocks, after the manner of coarse varieties of plutonic rocks. The largest exposure occurs at Kiandra township itself, and is from 15 to 20 acres in extent. A few blocks occur at the head of Whipstick Gully. A small patch near Charcoal Reef is associated with a small biotite granite boss. An outcrop, about 1½ acres in extent, occurs at the Eucumbene River below the basalt claim; and another in the Four-mile Creek.

At Kiandra the rock is basic, and exceedingly tough in character, by reason of the great amount of contained hypersthene.

Curious structures are noticeable in the mass, thin layers of varying basicity occurring in some of the blocks, giving the appearance somewhat of stratification.

The occurrence of small bosses scattered capriciously over the field points probably to the existence of a much more extensive mass below. The dykes associated with these bosses also weather out in spheroidal blocks.

These rocks do not appear to have suffered nearly so much from the agencies of metaphorphism as the older syenitic rocks.

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Gneisses and Granites.—The acid plutonic rocks of the district probably belong to the Carboniferous Period.

At New Meragle biotite granite possesses a decidedly banded structure. This rock has a fresh appearance.

At Rocky Plain, Governor's Hill, Alpine Hill, and Table Top Mountain a ternary granite occurs. The constituent minerals do not appear to have suffered much from metamorphic influences.

These acid rocks have a very extensive development, and their intrusions appear to have caused the pronounced crumpling in the local strata.

In the tuffs and slates very small granite bosses occur, one behind the Cemetery Reserve, one at Pig Gully, and one at Charcoal Reef, closely associated with a norite boss.

Quartz-felspar porphyries.—Irregular masses and dykes of acid porphyry occur in the district, and may be connected with the granite of Rocky Plain, although they have not been traced into any boss. They are decidedly younger than most of the igneous rocks of the locality, cutting across the line of strike of the syenitic rocks and the basic-andesitic dykes.

The Basalts.—These are of basic types, containing abundant olivine crystals. They occur as extensive sheets overlying Tertiary river deposits.

Several local eminences, having the shape of truncated cones, and composed in their upper portions of basalt, have suggested the probability of their being volcanic foci at one time. These points are known as Table Top Mountain, Round Mountain, and Selwyn Trigonometrical Station.

Table Top Mountain is 5,850 feet above sea-level, and is composed of tuffs (Silurian), slates, quartzites, and granites, having a thin capping of basalt, about 200 feet in thickness. The basalt on the eminence is at present isolated, and at its base between 200 and 300 feet above the Nine-mile Lead. Numerous inclusions of plutonic rocks, allied to syenites, occur in the basalt. A careful search was made for signs of volcanic eruption, such as tuffs or scoriæ; none were found. Mr. L. H. G. Young, formerly Geological Surveyor in the Department of Mines, mentions the occurrence of a solitary fragment of volcanic breccia* on the hill summit. It is very probable that this elevation formed one of a group of centres from which basalt was poured forth over the "leads."

Selwyn Trigonometrical Station is of similar formation to Table Top, consisting of Palæozoic tuffaceous rocks with a very thin capping of heavy olivine basalt. The basalt of the hill and in its near neighbourhood exerts a decided influence on the compass. Thus on one side of the trigonometrical station the deflection was 15 degrees; on another side it amounted to 35 degrees; while 1,000 yards away, on basalt of similar appearance, the deflection was as much as 65 degrees.

THE LEADS (1).

These are two in number, and may be called "The Kiandra Lead" and "The Round Mountain Lead." In both instances they lie beneath wide basalt flows, and the record of them is preserved only as the basaltic cap resisted the encroachments of the weather. The basalt itself, in the first instance, was determined in its main features by the course of the old rivers now constituting the channels of the present leads. The streams being diverted from their courses, cut for themselves other and lower channels, and have since been attacking the basalt mass. This from its superior hardness has resisted the various attacks made on it, while deep cañons

* Ann. Rept. Dept. Mines for 1880, p. 254.

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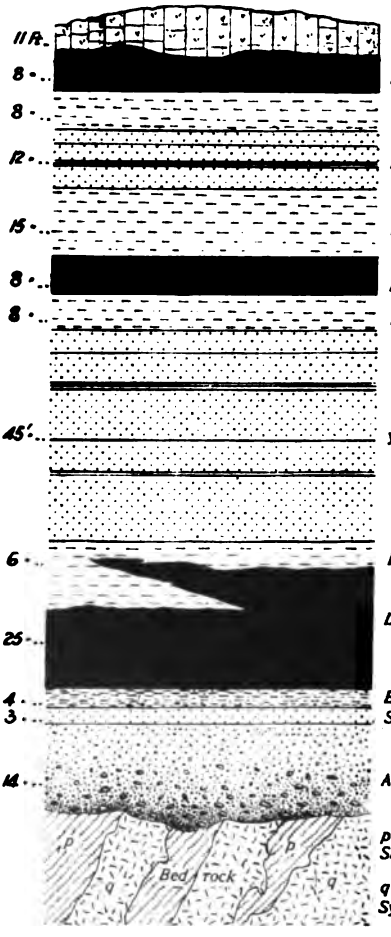
Section of Working Face . New Chum Hill

PATTINSON AND WRICKLER'S CLAIM



Columnar basalt

Earthy lignite altered by basalt.

Yellow clay

Red and yellow sand

Red and yellow clay

Lignite containing tree stems

Red and yellow clay

Coarse red and yellow sand layers

Red and yellow clay

Lignite and black shales containing numerous plant remains

Earthy lignite

Sand

Auriferous wash

p
Slates, claystones, and tuffs

q
Syenitic? dykes

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W. A. Gullick, Government Printer,
Sydney, N.S.W.

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have been carved out in the softer contiguous strata. But even the dense basalt has yielded in great measure to the stress laid upon it, partly by the action of severe frosts, and partly by percolating and eroding waters, until, as will be seen by glancing at the accompanying map, at least one-half of it has vanished, superficially considered.

When the basalt covering in part was removed, the soft underlying alluvium was quickly washed away.

The gold contained in the old channel would, however, remain for a still greater length of time, and while the wash itself disappeared, much of the gold would remain in more modern and neighbouring watercourses, although at lower levels than the parent channel.

Both of the deep leads have been proved over great distances.

The Kiandra Lead.

1. *Extent.*

Near Table Top Mountain the Kiandra lead has been proved by the excavations known as the Empress sluicing claim.

Here beds of lignite, clay, sand, and wash exist, having a total thickness of 160 feet. (*See* Diagram .)

From 10 to 15 chains beyond the "Empress" to the north a series of shallow shafts have been sunk in river drift similar to that occurring in the upper portions of the Empress.

Two miles to the north of the Empress, and under the same line of basalt, the South Bloomfield sluicing claim exposes another section of the old drift. Thence northwards the basalt has been worn away for a distance of nearly 2 miles.

At the point where the basalt makes again abundant evidence of the lead is present on the hill slope under the lava sheet in the form of wash, clay, and lignite, similar to that shown in the Empress and South Bloomfield claims.

Following the line of basalt known as Township Hill, various signs of the lead are apparent as one nears the northern portion of the hill.

In Pollock's Gully a shaft has been sunk through lignite and clay; two tunnels at the northern point of the hill have been driven through lignite and wash.

Lignite occurs also on the north-west portion of the hill, and close to the south-west corner of G.L. 60 a shaft 75 feet deep has been sunk through lignite and wash.

At the northern extremity of the hill, Bullock Head Creek has cut through the basalt, which latter is met with again on the southern portion of New Chum Hill.

Here for 40 chains along the southern boundary of the hill the various hydraulic sluicing claims known as Pattinson and Winckler's, the Cornishmen's, and Homeward Bound Claims demonstrate the presence of abundant drift underlying the basalt cap. (Frontispiece.)

Northerly, further evidence of the lead is present on the hillsides near the Giandarra, Luttrell's, and All Nations Claims. These also, consisting of tunnels and open cuts, have all proved the presence of wash and lignite similar to that obtained in the various sluicing claims already enumerated.

At this point a gap occurs in the basalt line, due to the erosive action of the Six Mile and Racecourse Creeks, the lava reappearing to the north at the Six Mile workings.

Similar wash to that found at New Chum and Township Hills is here exposed on the hillside beneath the basalt.

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On the main Tumut Road river sand is exposed on the roadside at the 50½-mile post, and underlying the basalt.

Further north again, at the Twelve Mile, and at a point where the Murrumbidgee River has cut across the basalt, Luttrell's tunnels have proved the existence of well-rounded wash beneath the basalt.

Wash has also been reported beneath the basalt from various places north and south of the above limits, *e.g.*, at a spot several miles to the south of Table Top Mountain and a locality some 20 miles north of the Twelve Mile.

2. *Argument in favour of lead instead of lake formation.*

The existence of a lead at Kiandra has been denied by many. The contention is that similar wash occurs at the Fifteen Mile, the slopes of the Tumut River, the Eight Mile, New Meragle, and other places ; that the latter are altogether off the line of the supposed Kiandra Lead ; and that the evidence is rather in favour of a large lake formerly stretching across Monaro, and embracing the country from Happy Jack, Tumberumba, and Broken Cart.

If a lake, the bed should not be altogether confined throughout its length between narrow walls; and the drift should not be of an even thickness throughout, but should form overlapping masses of water-worn material thicker in places than others.

On the other hand, if the wash can be shown to be confined to a long narrow channel, the levels of the bed-rock under the wash to be possessed of a continuous rise or fall as one passes the various claims in any given direction of length, and the wash to be evenly distributed along its length, then the evidence in favour of an old river-bed is undeniable.

(*a*) Evidence derived from study of the old channel banks.

At the Empress Claim (Nine Mile) bed-rock occurs to the north-west, rising above the base of the wash to a height of 50 feet. Ten or fifteen chains to the north the older rock is 150 feet higher than the lowest portion of the drift, and shuts the old channel off to the east under the basalt.

To the east again, and at a distance of some 40 or 50 chains, the bed-rock may be traced for a considerable distance beneath the basalt, and rising high above the level of the wash.

In the immediate vicinity of Table Top Mountain the wash has been removed by atmospheric agencies; but here, also, it was extremely narrow, for the high ridge of rocks forming the main Snowy Range confines it to the east, while to the immediate west the country rock is considerably higher than the old channel level.

At the South Bloomfield the wash is surrounded on three sides by high ridges of rhyolites and tuffs, the old channel being open towards the basalt only on the south-west.

At the North Bloomfield the original channel is well exposed ; but, to the west, there is no sign of it, the place being occupied by rhyolite tuffs and slates much higher than the wash level. These tuffs and slates may be traced beneath the basalt on the west side of Township Hill, signs of the old channel becoming abundant only near the northern point of the hill at G.L. 60.

Similarly the channel is enclosed to the east of the same hill, the bed-rock outcropping beneath the basalt at heights considerably above the base of the wash. At Basalt Claim signs of wash are frequent. Here it is again confined (*see* Diagram), and from a consideration of the distribution of the basalt probably belongs to a tributary of the main stream.

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Behind the Cemetery Reserve, in Commissioner's Gully, and on a large spur enclosing Pollock's Gully to the south, the enclosing of the old channel is specially well marked.

The spur just mentioned, composed of felsites and tuffs, rises some 300 feet above the wash, and stretches for over half a mile into the valley below, forming a huge buttress to the basalt-capped hill.

Immediately behind this shoulder of bed-rock, lignite and clay crop out in Pollock's Gully. As these are, however, 150 feet above the base of the wash in Township Hill Tunnel, 50 chains away, they probably represent the upper layers of the made ground. Here, also, immediately to the east of the shaft, the bed-rock outcrops some 120 or 130 feet above the wash level.

Thence to Township Hill Tunnel the bed-rock is from 70 to 100 feet above the auriferous wash, with, possibly, a slight outletting of the channel in the vicinity of Wesselman's Tunnel.

At the north-east corner of Township Hill the channel appears to be exposed in a natural section. Here pebbles, sandy wash, clay, and lignite over 100 feet in thickness outcrop on the hillside. (Plate VI.)

Across Bullock Head Creek the wash is well exposed on the southern end of New Chum Hill. By sluicing and tunnelling the channel has here been proved to have (over a distance of 40 chains) a narrow course rarely exceeding 10 chains in width, and confined on both sides by banks of tuffs and tuffaceous slates, and to have a westerly course.

Thence towards the northern point of New Chum Hill the channel appears almost totally confined beneath the basalt capping of the hill.

In Garden Gully, on its southern side, the bed-rock rises 100 feet and over above the level of the wash in the various claims just named. On the north side of the gully the basalt talus is excessively thick, concealing all traces of the underlying rocks.

A high spur of slates encloses Garden Gully to the north-east, shutting the channel off on the east. Immediately to the north of the spur signs of wash are abundant on the hillside beneath the basalt.

Here also the Giandarra and Robyn's Tunnels, Luttrell's and All Nations' Claims have proved the channel over a considerable distance, though they have not settled beyond doubt the width of the wash.

Near the All Nations' Claim the channel has been cut across by later streams.

Some 10 chains to the west the bed-rock (an igneous variety) rises 100 feet above the wash, and forms the western channel bank.

Thence for several miles to the west and south, following the basalt along New Chum Hill, the bed-rock can be traced at a much higher level than the wash.

At Reid's Gap the slates are 150 feet higher than the channel bed.

From All Nations' Claim to the north both basalt and wash have been removed by the forces of erosion over a distance exceeding 2 miles.

At the Six Mile workings the basalt is picked up again, and with it the auriferous wash, its cappings of lignite, clay, and sand. Here, again, as at New Chum Township and Nine Mile Hills, the channel is confined between high eastern and western banks of rock for miles, by way of Gooandra Trigonometrical Station.

On the main Kiandra-Tumut road, 10 chains north of the 50-mile peg, much sandy river material is exposed beneath the basalt in the road cuttings, and enclosed on both sides by slaty rocks.

At Lander's old tunnel, about a mile west of Tantangara Creek, the wash has again been proved, though its exact width has not been ascertained;

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also in two other tunnels driven by the same person, one about 10 chains from the Murrumbidgee River, the other at a spot where the Murrumbidgee has cut through the basalt cap.

The various points just enumerated, at which the old channel has been confined within narrow banks, are all indicated on the accompanying map.

(*b*) Evidence from character of the wash.

Wherever exposed, as at the Six Mile, New Chum, Township, and Nine Mile Hills, the drift has a fairly uniform character and thickness (*see* sketch sections across the various claims).

More or less auriferous wash is always overlain by layers of earthy lignite, clay (with thin bands of ironstone at the Four Mile and Nine Mile Claims), and sand layers, and the amount of made ground is almost without exception from 150 to 170 feet in thickness.

(*c*) The evidence of the levels.

Levels were run with a dumpy from the Six Mile to the Bloomfields. The heights of outlying points, such as the Nine Mile and Twelve Mile workings, were ascertained by means of an aneroid.

Starting with the lowest wash observed in the Old Six Mile workings as a bench-mark, and passing each claim in succession southwards to the North Bloomfield, the levels obtained are as follows:—

	Feet.
1. Six Mile workings (lowest portion of wash seen)	0·000
2. Giandarra Tunnel mouth (nearly on same level as wash) ...	9·770
3. Pattinson & Winckler's Sluicing Claim (base of wash) ...	31·980
4. Homeward Bound Claim (base of wash)	32·548
5. Township Hill Tunnel mouth (approx. same level as wash)	58·085
6. North Bloomfield (base of exposed wash)	309·525

Combining aneroid and dumpy level readings, commencing with the wash at the Twelve-Mile as a base, we have the following:—

	Feet.
1. Twelve Mile (Lander's claim)	0·000
2. Six Mile workings	226 915
3. Giandarra Tunnel mouth	236·685
4. Pattinson & Winckler's Claim	258·895
5. Homeward Bound Claim	259·463
6. Township Hill Tunnel mouth	285·000
7. North Bloomfield	536·440
8. South Bloomfield	641·440
9. Empress Claim (Nine Mile)	785·000

There is thus a fall of 785 feet from the Empress Claim to the spot where the Murrumbidgee River cuts through the basalt at the Twelve Mile, a distance, measured along the road, of 20 miles.

By dumpy level the difference between the Giandarra and Homeward Bound Claims, is 22.750 feet.

There is thus very little fall in the New Chum Hill wash, although large potholes occur in the old river channel.

From the North Bloomfield to the Township Hill Tunnel mouth a fall of 251.440 feet was measured. As the Basalt Claim wash, 2 miles to the south, is very little higher than the entrance to this tunnel (25 or 30 feet),

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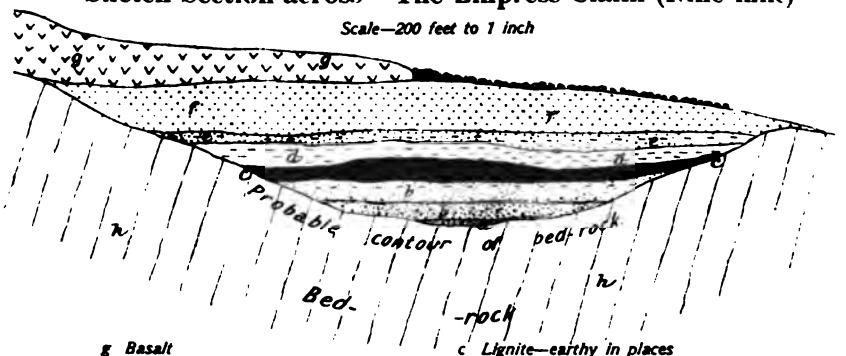
Sketch Section across The Empress Claim (Nine-mile)

Scale—200 feet to 1 inch

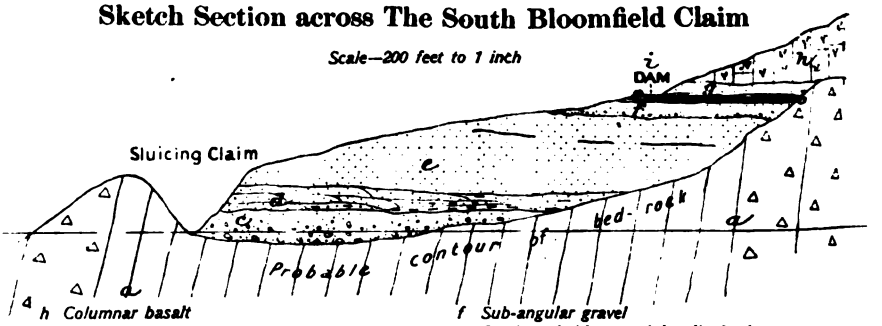


g Basalt
f Sand and fine gravel
e Pipeclay and sand
d Stiff clay
c Lignite—earthy in places
b Gravel, sand, clay, and ironstone layers
a Payable wash
h Tuffs, slates, and quartzites

81375

Sketch Section across The South Bloomfield Claim

Scale—200 feet to 1 inch



h Columnar basalt
g Sand
b Lignite
i Dam in lignite, 145 feet above base of wash
f Sub-angular gravel
e Sand, probably containing lignite layer
d Sand and clay showing current bedding, 30 feet
c Wash and sandy gravel, 25 feet
a Tuffs

81375

The wash is enclosed to the east, north, and west by bed rock (tuffs), rising to a considerable height above it.

To the north-west the tuffs are 175 feet higher than the wash.

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W. A. Gullick, Government Printer,
Sydney, N.S.W.

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the bed of the channel should be fairly flat over a considerable distance to the south, but thence to the North Bloomfield a sharp rise may be expected to occur.

From a consideration of the foregoing it will be seen that from the Twelve to the Nine Mile, a distance of 20 miles, the channel has been proved to be very confined, very rarely exceeding 10 chains in width, and possessing a more or less auriferous wash some 50 yards in width; that it has a meandering course; that the old drift is very similar in geological character throughout, consisting of auriferous wash (of varying value), earthy lignite, sand and clay layers with an uniform thickness of 150 to 170 feet; and that a constantly decreasing level exists between the claims of the Nine and Twelve Miles.

It thus fulfils all the conditions required for it as a river, while the conditions are altogether opposed to those obtaining in a typical lake.

Description of Claims, and Auriferous Contents of the Lead.

(*a.*) The Empress Claim and Neighbourhood.

Very rich waterworn gold was found in Scott's Gully, and by working up this watercourse, the gold was traced into the old drift underlying the basalt.

At this point the lead was found to be exposed in natural section on the hillside.

From the sluicing claim started at this point and named the Empress, considerable quantities of gold have been obtained similar in character to that obtained in Scott's Gully surfacings.

In the sluicing claim the whole of the wash was taken, no distinction being made between the rich auriferous channel and the poorer and higher contiguous wash.

A rough estimate made by Mr. J. M. Lette, (the proprietor) of the ground treated by hydraulic sluicing, together with a larger area adjoining it and treated by surface sluicing amounted to 60,000 yards, yielding £1 per yard.

Certain yields from sluicing operations at the Empress Claim during the years 1884–1889, and supplied by Mr. J. Pattinson, senr., from the Company's books, amount to 3,400 yards, sluiced for a yield of 496¼ oz. gold.

On the suspension of sluicing operations (owing to the difficulty of removing the "overburden" of basalt, &c.) a main tunnel was driven in about 2,000 feet, and from 30 to 33 feet below the lowest wash exposed in the sluicing claim.

An upper tunnel was driven through the wash, keeping as nearly as possible to the centre of the auriferous channel.

Cross drives have been put in on each side of this upper tunnel for about 50 to 75 feet to prove the wash.

"In all about 1,000 feet along the channel are now ready for blocking out, which should yield 12,000 superficial yards of wash averaging 4 dwt. to the yard." (Mr. J. M. Lette, Proprietor.)

Two dishes of dirt taken from the centre of this area, and washed in my presence, yielded about 3½ grains of gold.

In the Nine Mile Creek, wonderful yields of waterworn gold were obtained in the early days of the field, and, as in the case of Scott's Gully, the gold has been traced up the watercourse to a point where it disappears under the basalt.

The amount of gold won in Scott's Gully and Nine Mile Creek cannot even be approximately arrived at, owing to the non-existence of records of gold yields, but from all accounts it was very great.

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(*b.*) The South Bloomfield.

This claim (sluicing) never yielded gold to any extent, but it must be remembered that the prospectors have here only touched the wash, and do not appear to have gone nearly deep enough to prove the lowest portions.

This will be evident from a glance at the accompanying sketch section.

Here it will be seen that the excavation is mostly in bed-rock and the channel dips away from the open cut into the hill.

The Four Mile Creek, in the break between the North and South Bloomfields has yielded great quantities of coarse gold, said to be indistinguishable in character from the gold of the lead.

All along the course of this creek, between the limits just mentioned, large angular and subangular fragments of quartzite occur similar to those seen at the Nine Mile and covered partly by the basalt.

It is very probable that these quartzite masses represent conglomerates or the upper wash of the lead, altered to quartzites by the heating action of the basalt, and have remained owing to their hardness, while the softer parts of the wash have been removed after the denudation of the basalt cap, and that the gold present in the creek also represents, in great part, that which was originally contained in the lead, although the bed of the lead was some 200 feet higher than the level of the present stream.

(*c.*) The North Bloomfield.

This claim like the South Bloomfield was taken up as a sluicing area. A deep tail-race was cut and an excavation made in the hillside some 5 chains long, 1½ to 2 chains in maximum width, and 50 feet deep.

This claim has not produced much gold, but the remarks made concerning the South Bloomfield are applicable here also. It is almost certain that the deepest ground has not been touched. (See diagram .)

At this point and for some distance southwards the lead appears to be confined beneath the basalt and does not show on the side of the hill.

(*d.*) Basalt Claim and Tunnel.

These claims occur on a steep spur of Township Hill overloooking the Eucumbene River near its confluence with the Four Mile Creek.

Basalt Claim was taken up as a sluicing area. Very little work was done and the returns were poor. The hill, at this point, cannot be said to have been properly tested.

The diagram represents a sketch section based on measurements obtained at this claim.

Basalt Tunnel is a little more than 40 chains north of the latter claim, and consists of a tunnel driven some 300 or 400 ft. into the hill beneath the basalt. Well rounded quartz wash was obtained from the tunnel. The channel was auriferous, but was never properly tested.

The wash, lignite, and sand amount to fully 120 feet as determined by aneroid readings.

A section through this claim would be very similar to those obtained at the North and South Bloomfields.

Gold was obtained in the small gully leading from the tunnel to the Eucumbene River.

(*e*) The northern portion of Township Hill.

In Pollock's Gully, at the township of Kiandra itself, wonderful gold yields were obtained. The gold was said to be partly waterworn and partly ragged, like that found in the lead itself.

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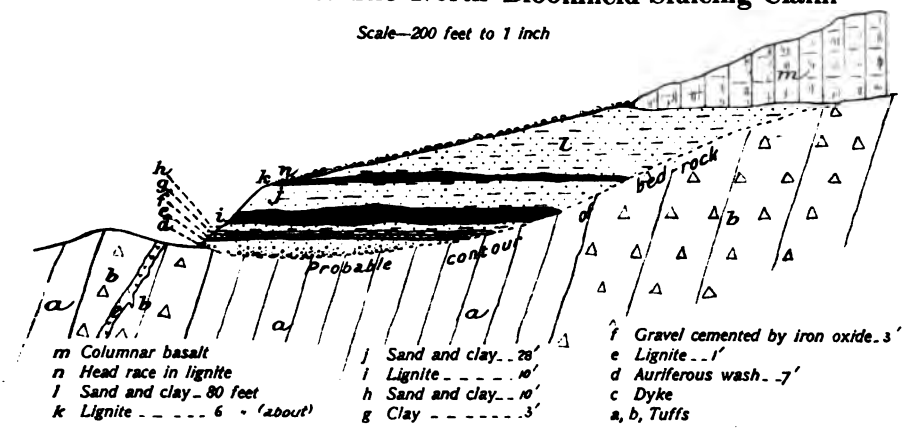
Sketch Section across The North Bloomfield Sluicing Claim

Scale—200 feet to 1 inch



m Columnar basalt
n Head race in lignite
l Sand and clay.. 80 feet
k Lignite ..... 6 " (about)
j Sand and clay.. 28'
i Lignite ..... 10'
h Sand and clay.. 10'
g Clay ..... 3'
f Gravel cemented by iron oxide.. 3'
e Lignite .. 1'
d Auriferous wash.. 7'
c Dyke
a, *b*, Tuffs

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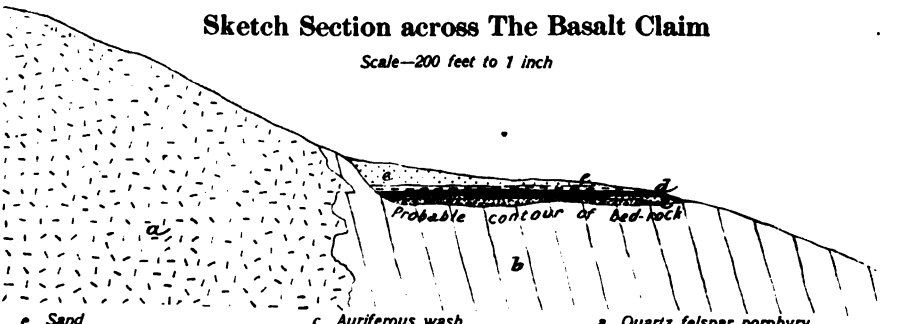
The slope of the working face is shown in the sketch, and the lowest part of the auriferous wash has evidently not been exposed.

Sketch Section across The Basalt Claim

Scale—200 feet to 1 inch



e Sand
d Clay, Lignite, and sand
c Auriferous wash
b Tuffs
a Quartz felspar porphyry

Forty chains to the north, the river gravel and lignite are together 120 feet thick, overlaid by basalt.

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HOMEWARD BOUND OPEN CUT.

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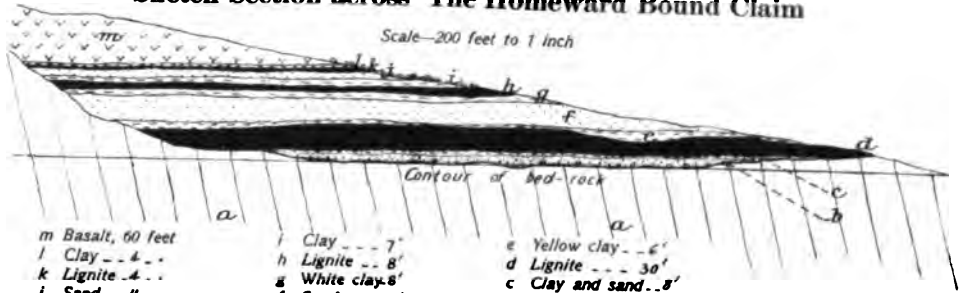
Sketch Section across The Homeward Bound Claim


Scale—200 feet to 1 inch
Contour of bed-rock
a
a
m Basalt, 60 feet
l Clay . . 4 . .
k Lignite . 4 . .
j Sand . . 11 . .
i Clay . . . 7'
h Lignite . . 8'
g White clay 8'
f Sand . . . 30'
e Yellow clay . . 6'
d Lignite . . . 30'
c Clay and sand . . 8'
b Auriferous wash (well-rounded pebbles), 12 feet
a Tuffaceous rocks

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Hydraulic Sluicing at Pattinson and Winckler's Claim.

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